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Forthcoming Events.

APRIL 1.

West of Scotland Iron and Steel Institute:—Annual meeting at Glasgow.

Society of Chemical Industry (Manchester Section):—Meeting at Manchester. "The Work of the National Physical Laboratory." Paper by Dr. W. Rosenhain.

APRIL 8.

Institute of Metals (Sheffield Local Section):—Ordinary meeting. "Refined Silver for Electro-plating Anodes." Paper by E. A. Smith, A.R.S.M.

Institute of British Foundrymen.

APRIL 2.

Lancashire Branch:—Annual general meeting at Manchester. "Absorbed Gases in Iron and the Creation of Gas Holes in the Casting." Paper by Ben. Hird.

APRIL 8.

Middlesbrough Branch:—Ordinary meeting at Middlesbrough. "Combustion of Coke." Paper by Wm. Diamond.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Example and Precept.

During the past six years, the founding industry has had a decidedly difficult time. Had it been possible to make any improvement by reading reports, a decided improvement should have set in, for the past two years has seen a positive avalanche of diagnoses of the causes of trade depression, together with possible remedies. The most weighty pronouncements have come from the Government, which is daily criticised for its alleged failure to curb departmental extravagance.

In 1924 what is known as the Balfour Committee on Industry and Trade was set up, and produced in 1925 a survey of British overseas markets. This was followed last year by a survey of industrial relations, which dealt at length with important questions of population, wages, conditions of labour, and unemployment. Now a third report, in itself part of a still larger document, called "Factors in Industrial and Commercial Efficiency," has been issued. These reports are about 500 pages long, and we fear that few foundrymen will be able to give them thorough consideration. The last-mentioned deals fully with important changes in the economic organisation of industry in this country, and present conditions relating to employment and training of industrial recruits. The most interesting section to many will be that dealing with scientific research, while those engaged in the production of light and ornamental castings will be interested in the portion devoted to industrial art.

In connection with important educational questions, a Consultative Committee of the Board of Education, on which we look in vain for the name of any well-known industrialist, has issued a report on the Education of the Adolescent, dealing with the relationship between education and industrial requirements. On the whole the conclusions will not be discouraging to those business men who want intelligent and well-educated young people, but the proposals form essentially a development of the present system, and there is no sign of any striking change. Two other committees were set up respectively for England and Wales and for Scotland to deal with the difficult question of unemployment among young people, and the former committee has reported.

It is convenient at this point to note that the report of the Privy Council Committee for Scientific and Industrial Research has just issued its report for 1925-6. The arrangement for further five years' assistance to the Cast Iron Research Association is mentioned, and it is pointed out that there is little to criticise in the present organisation for metallurgical research, but that it will rest with the industry to make the best and quickest use of advances in knowledge. It is also pointed out that it would not be reasonable to expect every foundry to maintain an adequate technical branch, but that co-operative research can be carried out at a trivial cost when shared.

XUM

Practical Crucible Steel Melting.*

By J. F. Kayser.

(*Continued from page* 255.)

Runners.

Runners can be primarily divided into two categories:—(1) Defects in the pot when it leaves the pot house; (2) defects developed in the furnace. No. 2 can again be divided into:—(*a*) Defects developed during the annealing of the pot; (*b*) runners caused through lack of skill on the part of the furnacemen; (*c*) runners caused by the use of unsuitable material or of materials impossible to melt.

Pots are liable to damage at every stage, the first place where the furnace team is responsible being in the annealing grate. On occasion pots are actually broken there, but the usual cause of defects which originate in the grate are due to the annealing temperature having been either too high or too low. When the temperature has been too low the pot has a great tendency to rent up from the bottom, and the fracture is somewhat dull looking and earthy. When a pot has been hot-annealed it will look quite white after it has been in the furnace, and, on analysis, will be found to contain no carbon. Hence these two types of defect can be recognised in one case by the fracture combined with the position and nature of the damage, and in the second case, *i.e.*, in the case of a hot-annealed pot, by the white appearance of the fracture. A cold-annealed pot will usually start to run immediately the charge becomes molten, but with care a hot-annealed pot can be used, and may, on occasion, survive the first round, but it will not stand a high temperature, and shows a very great tendency to crush under the weight of the cokes and to be distorted by the outward pressure of the charge. If a pot has been annealed normally and is then allowed to go cold before being placed in the furnace, or if there is insufficient lighting-off fire, it will usually rent in very much the same manner as a cold-annealed pot. That, however, is a very infrequent occurrence. Bad sanding can also give rise to runners. The sand may at first frit and then suddenly break away from the bottom of the pot and float to the surface of the molten charge. On the other hand, sufficient sand may not be used to cover the spindle hole or to make good the bottom. It is also possible that the pot may be steeled before the sand has had time to frit and a piece of metal may find its way through to the spindle hole. If the sand has not been allowed to frit or if insufficient sand has been used, the charge will drip through into the cellar as it melts. If, on the other hand, the sand comes up, it will happen suddenly after the charge has melted, and the whole of it will be lost in a few minutes. It is impossible to stop runners due to the above cause, but the pot can be sanded again and used for the second round. In fact, even in the case of a rented pot, it is often possible to sand to above the rent and so be able to use the pot at least once. One also finds pots which appear to have been annealed normally but yet show rents. That may be due to the pot having been mechanically damaged before being annealed or being severely jarred when being placed in the furnace. Such rents usually give rise to runners in the first round only, but, on occasion, if the rent is in the mouth, it may gradually spread downwards and ultimately give rise to a runner in a subsequent round. For the above six causes of runners the responsibility rests with the furnacemen. It is interesting to note that none of the above defects occur in the case of plumbago pots.

Bad Steeling.

Bad steeling also gives rise to runners with equal facility in either the first, second or third round. Crucible pots are extremely strong and elastic at high temperatures, and are not often damaged by a piece of scrap falling in heavily, though there is a slight risk of that. Usually, however, runners due to bad steeling are caused by a long piece of metal being jammed across and bursting the pot as it (the steel) heats up and expands. On the other hand, when melting certain types of iron which lay very heavily in the pot, it is impossible to avoid the production of a burst pot. The author has in mind certain types of horse-shoe iron, which are particular offenders in that respect.

When a pot runs on account of bad steeling of the latter type, the damage may at first be put down to a cold-annealed pot or to one of the other causes of renting, but it will usually be found that a large number of pots containing the same type of charge will burst together and that, otherwise, the pots will appear perfectly sound. When a pot is burst by a piece of steel becoming jammed across it, the defect will usually take the form of a gash in the side of the pot, which may run at any angle, and it is frequently possible actually to see a mark at one side of the pot where the offending piece of scrap became jammed. Both the plumbago and clay pots are liable to be damaged in this way, and the blame can be laid in some cases at the door of the furnacemen and in others the responsibility rests with the mix-shop. The latter may, for instance, send in weighs which it is quite impossible to keep "open," and they may also bury a long piece of scrap amongst smaller material. It might be mentioned that one of the best ways of loosening a charge, which tends to lie heavily and solidly, is to introduce a small quantity of sheet scrap or tube scrap.

By far the greater number of runners are caused by too much fire, *i.e.*, the holes are allowed to attain such a high temperature that the strength of the pots is no longer sufficient to withstand the outward pressure. That is a type of defect usually found in the second round, but it may also occur in the first. It is very easy to recognise runners due to that cause, as instead of the surface of the pots having a general uniform appearance it will appear spongy. That sponginess is often noticeable after the first round in one place only, and the pot may be otherwise quite sound. When returning such pots to the hole for the second round they should always be placed so that the weak and damaged portion goes "in between them." It is quite impossible to damage plumbago pots by too much fire, and in that respect they are much superior to clay pots. When clay pots are very hot they may sometimes be damaged when being handled. The pulling-out tongs may not be placed on securely, and one of the bits may penetrate the walls. When a barrow is used there is sometimes also a tendency for the ends of the bits only to be utilised, with the result that they dig into the pot and cause trouble. Pots can also be broken on the floor, but that usually does not occur when making small ingots, as, when hot, pots are strong and tough and are usually not damaged if they fall over.

Runners due to "clinked" pots can only occur in the second round. They are due to the pot having been allowed to get too cold before being replaced in the furnace, or they may be caused by the charge being steeled into them before the coking-up fire has had time to burn through. In any event, it is quite easy to recognise this type of defect, as the pots present exactly the same appearance as a cracked piece of porcelain. Both these last two troubles are again at the furnaceman's door, and it is interesting to note that these causes of runners occur only in the case of clay pots and not with plumbago pots.

"Muck" holes give rise to a considerable number of runners. "Muck" holes and air-shuts are often classified together, as it is frequently difficult to tell one from the other, and, in any event, both are due to faulty pot-making. It is extremely difficult to recognise this type of defect in all cases. Usually, however, one will find that the pot appears perfectly sound and does not show any signs of too much fire, and that the metal will break out suddenly and abruptly in one particular place. In every case the charge is to blame. The trouble may be

* Paper read, February 22, before the Sheffield Metallurgical Association.

caused by the use of rusty scrap high in manganese or by an alloy with alkaline impurities. The appearance of flux holes and washed pots is so obvious that no description is necessary.

The question that is of particular interest is: Is it possible to stop a runner, and, if so, how? When a runner is due to the pot being cold-annealed, and rent or split from the bottom due to any cause, it is quite impossible to stop it running when it has once started, and the best thing to do is to get it out as soon as possible, empty out the charge and return the pot to the hole upside down and so save cokes. When the runner is due to bad sanding it is also quite impossible to stop it when it has once started. The pot may, however, be re-sanded and will be quite sound and suitable for the second or subsequent rounds.

When pots run from any other cause than those already mentioned, steps can be taken to save them. Immediately a runner is reported the puller-out should go into the cellar and see whereabouts it is running. If there is not too much fire in the hole it is then possible to examine the pots from above, and one can frequently see the steel running down the side of one of the pots. A handful of sand thrown into the hole helps considerably to find exactly where the defect is. If the defect is very high up the pot can be laid on its side so that the defect is above the metal line, and matters may be further helped by throwing a handful of wet clay on to the defect and pressing it home with the potter end. If the defect is so low down that leaning the pot over will not help matters, a temporary repair can often be effected either by pouring a canful of water on to the pot from above or by throwing it at the pot from below and then applying the clay as before.

It will be gathered from the above that the furnacemen must take the greatest possible precautions to prevent the pots being damaged during use. It is often stated that the work could be made much lighter if mechanical means were adopted for removing the pots from the furnace. The author has seen such means adopted, but, in his opinion, mechanical appliances have not yet been found to be a success in a crucible furnace. It is not a difficult matter to pull out a pot containing 70 lbs. of steel, but it is not merely a question of putting on the tongs and bringing the pot out by main force. If that is done the pots are almost certain to be damaged, and the whole of the contents lost. When a puller-out "goes on" he first of all grips the pot high up the shoulders and raises it out of the fire and then drops the tongs right down and takes the first lift. One frequently notices a puller-out go to a hole, prepare to lift the pot and then suddenly release his tongs, step back for a few minutes, and then fetch the pot out. The reason he does that is, that immediately he touched the pot with his tongs he could tell that, on account of excessive temperature, it was not strong enough to withstand the stress which would be put upon it when it was lifted from the bars. On occasion it may, in fact, be necessary to throw two or three canfuls of water in the hole to cool the skin of the pot down quickly so that it may be immediately withdrawn.

If mechanical means are adopted the tongs must always be put on by hand and the pot loosened before the actual pull takes place, and, when making double ingots or larger, there is usually very little time to spare, and matters run more smoothly if the pots are man-handled the whole way. The author has read descriptions of machines which push the pots out, but he has had no practical experience of them, and so cannot pass an opinion.

Ingots.

Crucible-steel ingots vary in size from approximately 60 lbs. to 2,000 lbs., and the preparation of the mould depends upon its size and upon the type of steel for which it is being prepared. Moulds up to 5 in. square are almost universally prepared by being reeked. Larger-size ingot moulds are usually painted with tar, which is applied after the mould has been heated to a temperature of, say, 150 to 200 deg. C. The author very much favours the use of tar upon moulds, especially in the case of large ingots or when teeming a steel which is liable to splash. If the mould is only reeked the splash will usually adhere to the mould side, but if tar has been used it will be immediately thrown back into the body of the ingot whilst in a molten state.

The larger-sized ingots are usually made in solid moulds which are placed on a cast-iron bottom. When casting ingots of high-speed steel or high-chromium steel, the author considers that a cast-iron bottom is not sufficiently safe, as he has known bottoms 4 in. thick be burnt right through the first time of casting and the whole of the ingot lost. It is preferable to have a cast-iron box suitably slotted to take, say, an 18-in. square brick, which makes a very safe and reliable bottom. He also thinks it advisable to fasten the ingot moulds down to the bottom, as on several occasions he has seen an ingot mould "lift," and, on still more numerous occasions, he has seen ingot moulds hit by a swinging ladle with a result that a breakout has been caused. It is advisable to cast ingots of 800 lbs. weight and upwards through a ladle, but it is considered that it is better practice never to have more than, say, fifteen pots in the ladle at one time. That is to say, fifteen pots should be first teemed into the ladle and the stopper then released and the remaining pots teemed in one after the other. The ladle must always be hot and the lining and stopper, when the first ingot is teemed in, should be at, at least, 900 deg. C.

The author's objection to the use of large ladles is that crucible steel procedure is very liable to be upset by small occurrences. For instance, a pot of molten metal spilt about the floor has a tendency to cause delay and some consternation. Also an ordinary crucible furnace has usually provision for only one big mould at a time, and, if anything goes wrong with the teeming, the only thing to do is to throw the molten metal on the floor, and the author hence considers it preferable to have only a small weight of steel in the ladle at any one time, so that, in the event of a breakout or any other such eventuality, the loss may be reduced to a minimum. Ingots up to a half a ton in weight may be teemed by hand straight down the mould, but that again is an unsafe practice, as there may be some delay in bringing up a continuous procession of pots. When making ingots containing, say, 300 lbs. up to 800 lbs., a plumbago pot may be used instead of a ladle. It is necessary to drill, say, a $\frac{5}{8}$-in. hole through the bottom and to heat the pot up to a white heat before teeming through it. It is then usual to strike off with two "double" pots, and to continue with a further two "double" ones, followed by the rest "single." The plumbago pots mentioned in a previous part of the Paper can be utilised in this manner a large number of times, as, when the hole becomes worn too large, it can be filled with ganister, dried, re-drilled and again put into commission.

Ingots below, say, 5 in. square, are usually cast by hand into box moulds. In this country side tongs are universally used for teeming, but in foreign countries, where the labour is not so skilful, it is usual to use shank tongs, which enable two men to assist in the teeming of one pot. The author considers that the Sheffield crucible trade adheres too strongly to side tongs for teeming. A few furnacemen claim that when teeming with side tongs they can look down the mould whilst teeming, which is impossible when shank tongs are being used. The author, however, only knows one furnaceman who can look down his own mould when he is teeming, and most of them lean well back and cannot be said to have as much control over the pot as two men operating the usual type of double-handed shank.

Whatever method is adopted, it is necessary that the stream of metal should not impinge upon the sides of the mould. If it does so, a surface defect will straightaway be formed. In crucible-steel practice two types of defect due to imperfect teeming are met with, and the resulting ingots are known as "wiped ingots" and "caught ingots" respectively.

"Wiped ingots" are caused by the stream of metal coming so close to the side of the mould that the mould dressing is burnt off, or the stream of metal may actually touch the side of the mould, but not freeze on to it. When the molten

metal comes in contact with the part of the mould where the dressing has been removed reaction takes place, with the result that a spongy appearance is produced on the surface of the ingot. If the stream of metal comes into such abrupt contact with the side of the mould that it actually freezes on, the ingot is said to have been "caught." Sometimes the frozen strip of metal will fall away from the side and rise to the top of the ingot, when it is difficult to tell that the ingot has been more than "wiped" from an examination of the surface. If, however, the frozen metal remains in position on the side of the mould, the cause of the resulting defect can be readily diagnosed.

The surfaces of crucible-steel ingots should be free from blemishes; an ingot with a good surface and only moderately sound is more economical than a perfectly sound ingot with a bad surface. The shape of the ingot mould has little influence upon the solidity of the ingot, and, whilst the theories expounded by the wax-ingot school may be found to be effective when dealing with large-sized open-hearth ingots, etc., they do not apply to crucible-steel ingots weighing up to one ton.

When using box moulds parallel sides are preferable, but when using a solid mould it is necessary to have a certain amount of taper in order to be able to strip the ingot. The author is aware that this statement will meet with opposition, but, as a result of experience with tens of thousands of ingots cast in parallel moulds and taper moulds, he is firmly of the opinion that his statement represents the truth of the matter. The evidence upon which he bases these conclusions is as follows: For a considerable period he was regularly producing round discs approximately 8 in. in diameter and of random thickness varying from 3 to 12 in. These were required with a hole through the centre, so that it was a matter of indifference whether the ingots were sound to the centre or otherwise as long as defects could be bored out. These discs were made from round ingots 9 in. in diameter, which were turned down to 8 in. and then parted. At least 50 per cent. of the discs showed shrinkage cavities and centre looseness. When the order was completed there was considerable over-production of ingots, which were hammered down into the form of cogged bars of different sizes, and, in view of the defects which had been found when cutting open the ingots, these cogged bars were in every case cut into at least 4 pieces, and, in some cases, 8 pieces, and instead of finding, say, one piece of cogging in four unsound in the centre, practically every bar was perfectly sound, and the only unsoundness that was found was found in positions corresponding to the top and bottom of the ingot respectively. That undoubtedly showed that the type of defect which was present in those ingots would weld up in spite of the fact that the material in question was high-speed steel.

Some years previous to that, and at about the time when Mr. Brearley's very excellent book was published, the author received instructions to have ingots prepared with the broad end up and to make extensive trials of ingots cast in such moulds versus ingots cast in parallel moulds. The results, far from being in favour of the taper mould, were in favour of the parallel-sided mould. Ingots from both moulds were equally sound, but the taper ingots did not produce such good cogged bars as the parallel-sided ingots, as when cogging a taper ingot one face of the hammer must, at first, very obviously come in contact with a much smaller area than when working on parallel-sided ingots, with the result that "pulls" were very easily caused on the former.

With crucible steel internal unsoundness is a type of defect seldom met with in the finished bar, and it must be remembered that crucible steels are in every case used in exceedingly short lengths, so that if any defects are present they will certainly be found. On the other hand, surface defects cause a great deal of trouble, and it is the universal practice to grind out the slightest defects in the ingots and to again examine the cogged bars and grind out any trace of unsoundness or surface blemish. The author has in mind an instance well demonstrating the above. A steel containing 4 per cent. of nickel, 1 per cent. of chromium and 0.45 per cent. of carbon had been manufactured quite successfully in the crucible-steel furnace, but, on account of cost, it was decided to have it melted in a Siemens furnace. The author well remembers telling the works managers of one of the firms who undertook its manufacture that they need not trouble much about the centre of the ingot, but must devote all their attention to the production of an ingot free from surface defects. His remarks were completely ignored, with the result that more than one firm abandoned the manufacture of the alloy, and, at the present moment, such a steel can only be economically purchased from a foreign source. If, however, the English manufacturers would concentrate upon improving the surface and leaving the centre of the ingot to take a little more care of itself, there is no reason why it should not be possible to produce such a nickel-chromium steel at a competitive price in this country.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Semi-Steel.

To the Editor of The Foundry Trade Journal.

Sir, — Will you kindly correct an error in the report of the discussion on Mr. J. E. Hurst's Paper, "Semi-Steel," read before the Wales and Monmouth Branch?

I am reported to have said: "This was submitted to the B.C.I.R.A., who reported the patches were *entirely due to sulphur*."

The report is too long to give in detail, but a more correct statement would be: "Due to high sulphur content and unusual cooling conditions."

I felt it was only fair to the B.C.I.R.A. to correct this.—Yours, etc.,

Ben Hird.

"Woodcot," Upper Cwmbran,
Nr. Newport, Mon.
March 28, 1927.

Foundry Research.

To the Editor of The Foundry Trade Journal.

Sir,—Several interesting suggestions have been made recently in your columns with respect to research in foundry matters. Mr. Logan and Mr. Dews have suggested the desirability of formulating and standardising tests on foundry sands. I should like to take this opportunity of stating that over two years ago the Cast Iron Research Association recognised the unsuitability of several of the American tests for moulding sands when applied to the natural British sands. During the intervening period active work has been in progress with the object of testing various sand deposits and formulating tests which can be utilised by the founder. An influential Sands and Refractories Sub-Committee exists, and the participation of all founders interested in this is invited.

With Dr. Moldenke's Paper abstracted in your issue of March 17 many founders will find themselves in agreement, and the views put forward have been repeatedly stressed in various reports issued by the C.I.R.A. Two, with which all readers will be familiar, are Mr. Fletcher's exchange paper to the Syracuse Convention in 1925 and his "Cast Iron in 1926," which appeared in the "C.I.R.A. Bulletin" for January, 1927, and was abstracted in various technical papers.

In the editorial columns of your issues of March 17 and 24, it is suggested that the surface of a casting is a fruitful field for research. There is no doubt that this is a matter of very great importance, not merely from the point of view of surface finish, which appeals to many sections of the industry, but from the point of view of continuity, that is, the absence of surface cracks and fissures.

It only remains to be added that the number of such matters which can be taken up at any one time and the rapidity with which they can be pursued, depends entirely upon the support founders give to the Association.—Yours, etc.,

H. B. Weeks.
Chairman of Council, the British
Cast Iron Research Association.
44, St. Paul's Square, Birmingham.

Some Experiences with Malleable Cast Iron.*

By H. Field (Metallurgist, Messrs. John Harper & Co., Ltd., Willenhall).

(*Continued from page* 252.)

To obtain a good skin on the thinnest castings it is advisable to sieve the ore from time to time in order to remove fine particles, amongst which will be found a major portion of the more fusible components. In neglected stocks of ore this riddling may reduce the available ore by 30 to 50 per cent. and will then necessitate renewal of stocks as just described.

When the annealing ore is used there is a considerable increase in its sulphur content. Some of this sulphur can be detected as H_2S by adding dilute hydrochloric acid, but the proportion held in this way is really very small, the bulk being present in the oxidised condition. Part of this increase is due to oxidation of the can material, some possibly to contact with gases, but in the major part it is obtained from the castings themselves. This is shown by the increased sulphur in the ore which is found adhering to a casting, the sulphur contents of such ore being above the average of the old ore pile, even when the casting is under-annealed. As soon, however, as the metal reaches the stage of decarburisation at the outer edge, oxidation sets in and there is then a rapid removal of sulphur, and consequent increase in the closer layer of ore. This removal of sulphur from the iron has been dealt with more fully in a study of "peeling," but it may be mentioned here that the particular "peeled" casting referred to in Table III contained 0.59 per cent.

TABLE III.—*Sulphur in Annealing Ores.*

	Total S.	S. as Sulphide.
	Per cent.	
New ore	0.26	Nil.
Same ore after using once	0.47	0.027
Used ore from stock heap	0.67	Not determined.
Fine ore from surface of hard castings	0.65	—
Ditto well annealed ..	0.85	—
Ditto "peeled"	2.03	—
Scale from castings annealed in new ore	0.21	—

sulphur in the centre, but only 0.22 per cent. at the edge. This table gives some further figures for sulphur in annealing ores.

Annealing Pots.

One of the largest contributors to the cost of malleable castings is the annealing cans in which the ore and castings are placed for annealing. Poor quality cans give short life, but they also lead to wastage through "scaled" castings, where holes develop in the can and in addition entail extra labour in removing the large accumulation of scale from the ovens.

The development of a first-class annealing can along scientific lines has for many years been one of the greatest needs of the industry. The general practice, both of large can makers and of founders making their own cans, has been to market the cheapest possible product, irrespective of quality. The cupola charge consists mainly of old cans, heavily charged with scale, supplemented by scrap-iron and steel of the most variable character imaginable. The product then is a white iron, presenting a fracture honeycombed with blowholes, the life of which is determined by its weakest point. By a study of the heat-resisting properties of cast iron it is possible to develop a sound can of greatly-improved service value, which will give a lower annealing cost per cwt. of work than the cheaper but unsound can. For this purpose the desirable chemical properties are low silicon and phosphorus, medium sulphur and high manganese, together with low carbon. If silicon is allowed to fall too low, say below 0.4 per cent., the metal will always be unsound, whilst if phosphorus rises over 0.3 per cent. the can will soften and bulge at the annealing temperature. Such metal is illustrated in Fig. 9, being taken from a can which collapsed. High manganese is essential for maximum life and should be over 1 per cent. in all cases. The author has repeatedly made cans along these lines and obtained greatly improved results compared with the ordinary commercial can. More recently this specification has been adopted by one large can maker and is being worked to as near as practical and economic considerations permit. Owing to the varying length of annealing time used by various founders for the different sections of castings within their trade it is difficult to give details of service tests which could be comparable with other workers, but the tests have always been conducted by finding the can cost per cwt. of work annealed, by recording the number of days service given by individual cans, and by weighing batches of cans every time they come from the oven. A batch of cans made with 2 per cent. chromium was carefully followed through on these lines, but, contrary to expectation, no improved result was obtained.

FIG. 9. × 50.

ANNEALING CAN, 0.45 PER CENT. PHOSPHORUS. COLLAPSED IN THE OVEN. PHOSPHORUS IS SEEN IN CRYSTAL BOUNDARIES.

Nickel Chrome Cans.

A few years ago six nickel-chromium cans were received for test. This metal was an alloy of nickel and chromium with about 10 per cent. of iron, and as it had been successfully used for many heat-resisting jobs there seemed a possibility of an almost indefinite life for malleable annealing cans made from it. The cans were made of lighter section than ordinary iron ones, but even then a 14-in. round can weighed about 80 lbs. and cost £24, against a similar sized iron can weighing roughly 2 cwts. and costing at that time about 12s. Since the latter can give, say, 7 heats, the nickel-chrome can would be required to give something in the neighbourhood of 200 heats to be an economic proposition, apart from the large capital outlay involved in purchasing 250 or 300 such cans. The actual life obtained was 48 heats, or about 7 times the life of an iron can, but in view of the cost the experiment was deemed a failure. In considering such a proposition two further considerations must be borne in mind: the labour-saving through the decreased weight of the alloy can, and the absence of scale

* A Paper read before the Birmingham, Coventry and West Midland Branch of the Institute of British Foundrymen, Mr. D. H. Wood presiding.

in the ovens, which causes much work in removal and wear and tear of firebricks.

In spite of this failure, the experiment was a most interesting one, and opens up the possibility that somewhere between these two extremes—on the one hand cheap iron with all its disadvantages, and on the other hand expensive nickel-chrome alloy practically non-scaling—there may in the future be found a new material for this purpose.

Apart from test bars called for by the buyer of malleable castings, every oven should contain a selection of such bars distributed at those points known to give lowest, medium and maximum temperatures. Pieces from scrap castings comparable in section with the work being done should be included and used for drilling, turning and bending tests. Reference has already been made to the need for an appreciation of the buyer's machining requirements, and the author has found that a machining speed of about 90 ft. per sec. is a very good test of the machinability of the castings. This can be translated to drilling speeds for various sizes of drills and all sorts of bosses and sections subjected to test. Such a test will not only lessen rejects from the machinists, but will save labour on dressing, barrelling, etc., of castings whose only ultimate fate can be re-annealing. It should be needless to urge some such inspection, but the writer is personally aware that in some malleable foundries no such test is ever imposed, and all castings from the ovens are despatched direct to the customer.

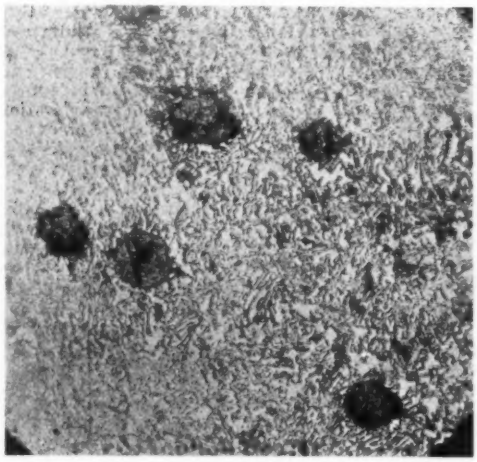

Fig. 10 × 100.
Hard Malleable Iron.
Centre.—Plenty of Cementite.

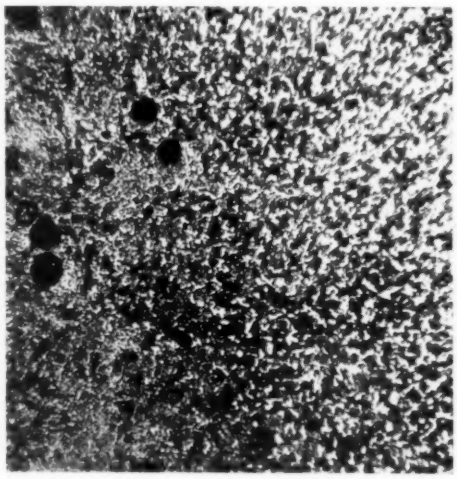

Fig. 11. × 50.
Hard Malleable Iron.
Edge.—There is still a Good Proportion of Combined Carbon Even on the Extreme Right.

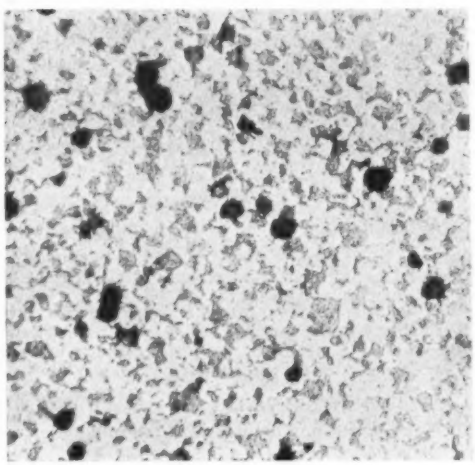

Fig. 12. × 50.
Malleable Iron with High Elongation and Bend.
Centre.

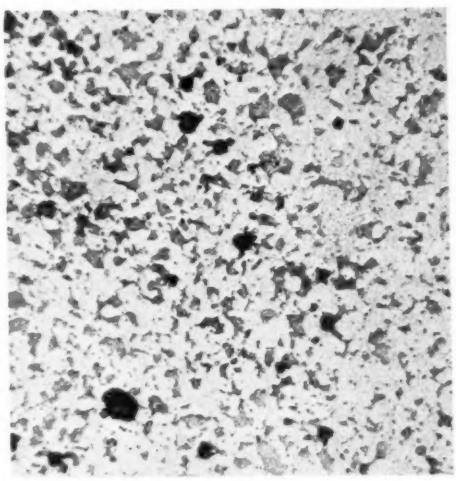

Fig. 13. × 50.
Edge.

Specifications.

Coming now to the question of the actual physical testing of cast iron, the B.E.S.A. have recently issued a specification (5,022/1923) for whiteheart malleable iron as follows:—*Ultimate tensile strength*, not less than 20 tons per sq. in.; *minimum elongation*, not less than 5 per cent. in 2 ins.; and *bend test*, 45 deg. round $\frac{3}{4}$-in. radius. (The tensile test bar is $\frac{1}{2}$-in. dia. in the central part.)

Although the writer assisted in the drawing up of this specification, he has always felt that the

diameter of the test bar is on the large size. The tensile strength of 20 tons and the bend test of 45 deg. present no difficulty if the iron is of reasonable quality, but a ⅝-in. bar needs to be well annealed to give 5 per cent. elongation. The purpose of the specification is in part to encourage the manufacturer to produce malleable iron of standard quality, and probably this purpose would be better served by requiring 5 per cent. elongation in 2 in. on a ½-in. diameter bar. Castings of section equal to these test bars will machine without difficulty if annealed under such conditions as enable the bars to give the specified tests, but on the other hand, bend test bars do not readily drill at the speeds previously referred to, unless the bend reaches about 40 deg.

The B.E.S.A. specification makes some suggestions regarding chemical analysis, but its demands are quite reasonable, since good malleable iron cannot be made outside the limits set forth, which read as follow:—The iron shall contain: *Silicon*, between 0.5 and 1.0 per cent.; *manganese*, not more than 0.4 per cent.; *sulphur*, not more than 0.4 per cent.; and *phosphorus*, not more than 0.20 per cent.

Against this may be set the specification issued by one of the principal makers of heavy automobiles, which specified six items in a chemical analysis and four in physical tests. In addition, samples were to be examined microscopically for defects, and might be rejected on the results of such an examination. The complete specification read as follows:—

Chemical Specification.—Total carbon, under 3.00; combined carbon, under 0.50; silicon, under 0.80; manganese, under 0.50; sulphur, under 0.25; and phosphorus, under 0.09 per cent.

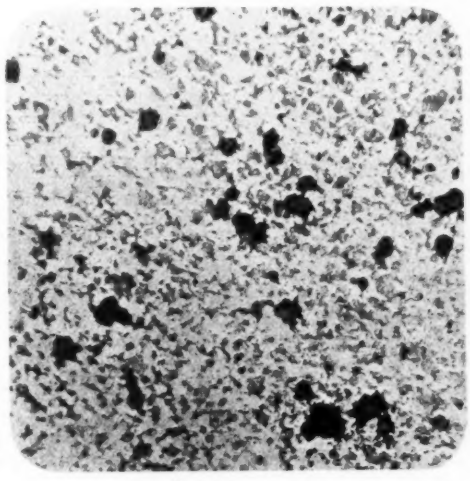

Fig. 14. × 50.

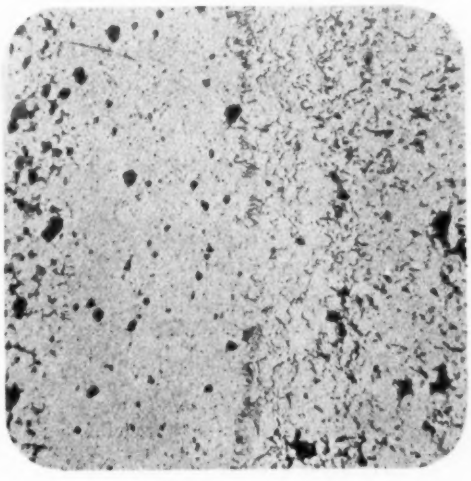

Fig. 15. × 50.

Showing How the Effort to Obtain very Low Carbon in the Bar Results in an Oxidised Edge. Oxide Penetration on the Right.

Centre. Edge.

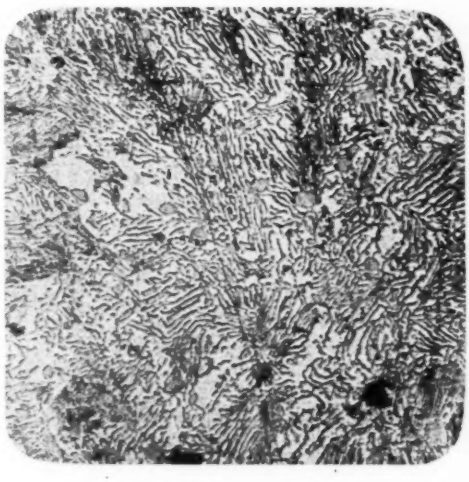

Fig. 16. × 250.

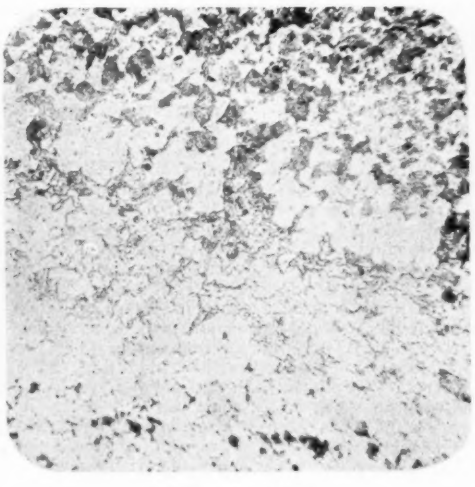

Fig. 17 × 50.

Showing how Malleable with a Hard Centre may still have an Oxidised Edge.

Centre. Edge.

A percentage of deliveries will be examined microscopically. If not clean, consignment will be rejected.

Good, clean castings, free from porosity, to be well annealed, and must fulfil the following physical specification:—*Tensile breaking strength*, over 22 tons per sq. in.; *yield ratio*, over 70 per cent.; *elongation*, over 15 per cent.; and reduction of area, over 10 per cent.

All tests to be carried out on a special test piece cast on and annealed with the particular part and tested without machining.

Please supply — test bars 12 in. long × 1 in. dia. with this order.

It is evident that the person responsible for drawing up the specification had no practical ex-

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perience in making or testing malleable castings, and on representations being made of the impracticability of the demands a vastly different specification was sent down and adopted. It is undoubtedly within the province of the buyer to limit the amount of any such dangerous element as phosphorus in malleable iron, since good malleable cannot be made with high-phosphorus, but to tie the manufacturer hand and foot is both unreasonable and impracticable.

During the writer's practice with malleable iron a ¾-in. diameter tensile bar was used, and the

Table IV.—*Physical Tests.*

	Tensile.	Elongation.	Bend.
Short anneal. Average of 17 tests. 1923	24.3	6.8	53
Short anneal. Average of 25 tests. 1924	25.1	6.7	43
Long anneal. Average of 80 tests. 1923	24.3	9.2	64
Long anneal. Average of 40 tests. 1924	25.1	8.0	55
Highest tensile test.. ..	31.0	4.0	30
Highest elongation ..	25.6	15.3	60
Highest bend test	22.8	8.0	95

bend bar 1 in. × ¾ in. Table IV summarises the results obtained in each of the years 1923-1924.

The fracture of the most ductile of these bars, those, for instance, with over 10 per cent. elongation, is dark grey in colour and amorphous in character. The fracture of malleable iron is an excellent indication of its quality. Fractures of metal very much unannealed are of a bright crystalline character, and this gives place gradually to the darker amorphous type of fracture, the centre being last to change. Where there is much brightness, brittleness naturally follows, and on the other hand, no fear may be entertained for metal with the dark fracture, as it will always be of excellent character.

Under the microscope the very bright fracture is found to correspond to combined carbon well over 1.0 per cent., *i.e.*, metal with free carbide. Such a case is shown in Figs. 10 and 11, which show the unannealed centre × 100 and the edge × 50, the latter still containing plenty of combined carbon. On the other hand, the ductile metal contains only 0.3 to 0.4 per cent. combined carbon at the centre and practically none at the edges. this being illustrated in Figs. 12 and 13.

It has been stated by some authorities that good whiteheart malleable iron should contain no pearlite, this being replaced entirely by ferrite and annealing carbon. No doubt this is a very desirable structure, but the writer has never found a piece of good whiteheart malleable iron without some pearlite at the centre, and thinks it unlikely that such metal is attainable in practice. The edge can be rendered free from carbon, but some pearlite always remains in the centre. If the annealing be carried any further, oxidation of the edges sets in and the iron then ceases to be of good ductile quality. Such iron is shown in Figs. 14 and 15, although even here some pearlite remains in the interior. As the annealing medium is strongly oxidising in character, it is natural that as soon as carbon is fully oxidised at the edge, the ore should attack the carbonless iron and the penetration of oxide commences. Indeed, if the annealing process be unduly hastened by the use of too strong an ore. the removal of carbon at the outer surface may take place at a rate greater than its replacement from within, and an iron with a hard centre may then have an oxidised skin. This is shown in Figs. 16 and 17, the centre being × 250 and the edge × 50.

(*To be continued.*)

A. D. Foulkes, Limited.—At the annual meeting of the shareholders of this company in Birmingham, recently, Mr. A. D. Foulkes who presided, said the statement of accounts was satisfactory having regard to last year's events in the industrial world. The net profit amounted to £10,938, making, with the amount brought forward, an available total of £14,225. It was expected the new premises would be occupied at the end of April.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

National Foundry Examinations.

To the Editor of The Foundry Trade Journal.

Sir,—I have read with interest the letter from Mr. J. H. List stating that he has been trying for years to get some Educational Authority to set examinations for students and apprentices on Foundry Practice and Principles.

I should like to point out that all full-time students of the Loughborough College who are preparing for the Diploma of the College are required to spend approximately two terms in the foundry engaged on productive work, and the examinations held at the end of each year contain questions dealing with foundry practice.

The College foundry is capable of making iron castings up to 3 tons in weight, has facilities for the manufacture of non-ferrous castings, and is provided with an up-to-date equipment, including examples of various classes of moulding machines for hand and power.

In addition to the day work, evening classes are held for apprentices, in which the students receive instruction in foundry work.

I am certainly very interested to learn that the East Midland Educational Union are now setting specific papers on foundry practice, and I think it is only fair to point out the opportunities offered to students in foundry work at this College.

One of the things that has always occurred to the writer as an anomaly is that so many technical colleges have attempted to teach patternmaking alone. With the exception of the mere training in the manipulation of wood-working tools, it always seems to me to be quite wrong to think that it is possible to give instruction in patternmaking unless this is backed up with some training in practical foundry work.

Yours, etc.,

James F. Driver,
Works Manager.

[Mr. List, Mr. C. A. Otto and a number of other gentlemen who teach foundry practice, whilst realising the facilities available at Sheffield, Glasgow, Birmingham, Manchester, London, and elsewhere, deplore the fact there is no certificate of a national character available, and if any institution, preferably a University, will arrange for the examination of external students, they feel that the work put in by themselves and their students will have been thoroughly worth while. We hope that the various bodies teaching foundry work will be able to come together and decide upon a common examining body, or several, if they are convinced that the industry will be the better served thereby.—Editor.]

Origin of Imported Castings.

Merchandise Marks Act, 1926.

The Board of Trade have received applications for Orders in Council to be made requiring indications of origin in the case of imported steel plates, rails, joists, angles, channels, sectional material of all descriptions, castings, forgings, rounds, squares, flats, hexagons, hoops, hot and cold-rolled strip; wrought-iron bars, hoops, sections, plates and sheets.

The Standing Committee appointed by the Board of Trade will hold an inquiry at 2 p.m. on Monday, April 25, and on the mornings and afternoons of April 26 and 27. Representatives of any interests substantially affected who desire to be heard in opposition should communicate with the Secretary of the Committee, Mr. E. W. Reardon, as soon as possible before April 19 at the New Public Offices, Great George Street, Westminster, where the Committee will hold their meetings.

Philip Chapman & Company, Limited, 5, Copthall Buildings, Copthall Avenue, E.C.2, have removed to King's House, 36-37, King Street, Cheapside, London, E.C.2.

Notes on Current Foundry Practice.*

By G. C. Castle (Sheffield).

Introduction.

Science in the foundry has played a very considerable part during the last few years. It is often stated that abroad, especially in America, the foundries are very much more advanced than in Great Britain. This statement is altogether untrue, with possibly the exception that we do not organise our foundries to the same extent. There is a real future in the foundry for the technician who has had a fair amount of practical training in the foundry, and science so introduced, which after all is only the correct way for obtaining the desired results, then the future is assured from a sound production point. Unfortunately, a good many proprietors do not realise what a foundry can do; in fact, some never enter it from one week-end to another, whilst at the same time they presume that the foundry should always produce sound castings.

Cupola Practice.

The opinion, based on practical observation, that ordinary grey cast iron should be capable of some improvement in quality can be traced back to the first decades of the previous century. However, even during the years of rapid economic growth the fact that cast iron had no competition to face precluded any pressing need for alteration in the adopted processes, even though developments in thermal technology with the resultant influences on the construction of power machinery and boilers, as also the tremendous advances made in the chemical industry and in trades connected with means of transport, etc., foreshadowed a demand for high-quality structural materials. Metallurgical knowledge, derived from a study of texture and application of chemico-physical testing methods and the use of the microscope, was applied during the close of the last century to the production of malleable iron, and in particular to cast steel, and a material more suitable in some respects for the construction of machinery, was brought upon the market. Iron foundries, however, sought at first to meet the competition which had now begun to make itself felt by more rationally conducted working and mainly by purely commercial methods. In short, they endeavoured to make grey cast iron attractive by considerable reductions in price, effected by the employment of managers preferably having had a commercial or technical mechanical training. This resulted in difficulties in the introduction of metallurgical working methods. In addition, a reciprocal exchange of practical knowledge and a beneficial working in common was considerably hindered by the harbouring of secret processes, which sprang from over-rating of methods of working and charging. It could therefore not be wondered at if foundries were gradually forced on to the very edge of their economic capabilities of competition against cast steel, which was continuing to develop qualitatively, and beginning to be used for purposes for which a high quality cast iron should have remained the particular structural material.

Endeavours to improve the quality of grey cast iron which were gradually being set into motion touched upon the essential point of all processes purposing such betterment, namely, the systematic reduction of total carbon content and the necessary increase in temperature to settle the furnace problem. The view that it is impossible during continued cupola working to maintain the carbon with certainty within specified limits, to keep it constantly and regularly below a content of 2.8 to 3 per cent., and to increase the temperature of the iron to an appreciable degree above 1,400 deg. C., gradually fostered the opinion that the cupola was no longer quite suitable for the production of high-grade cast iron and that it would have to give way in this respect to reverberatory and electric furnaces.

It furthermore was found that the cupola burden showed an increased tendency to take up sulphur from the melting-coke on increasing the amount of steel scrap or grades of low-carbon iron in the charge.

* A Paper read before the Institute of British Foundrymen (East Midlands Branch) and the Society of Engineers, Leicester.

Although doubtless no one would wish to dispute the advantages of the reverberatory and electric furnaces, which have fully proved their worth in foundry work from a metallurgical point of view, yet in the interests of further economic capacity for competition it is necessary in all circumstances to retain the cupola as long as its utility for the production of high-quality cast iron is not definitely refuted. From this point of view one should take up a carefully-considered attitude towards every attempt for improving cupola conditions of melting from a qualitative and thermo-technical aspect.

During the last few years a great deal has been heard of various processes for improving cast iron, some of which have proved fairly satisfactory, whilst others are quite useless for adopting as a general process to the majority of foundries. Careful thought should be given to new processes, and one must not run away with the idea that such processes even when adopted do not require a little time, trouble and further experimental work to fit them in any particular foundry. The testing of cast iron, apart from the analysis, requires care. It is usual to take transverse and tensile tests, but for castings that require to be put into machinery, and engine parts, which are subject to wear, then the abrasion test is essential. Table I shows such tests on three samples of cast iron, each sample possessing a different analysis.

Abrasion Tests on Three Samples of Cast Iron.

Materials tested.	1	2	3
Size of blocks cast ..	2 in. sq.	2 in. sq.	4 in. sq.
Analyses.			
T.C.	3.45	3.13	2.03
Si.	0.91	0.70	2.30
Mn.	0.79	0.86	0.70
P.	0.22	0.18	0.11
S.	0.10	0.12	0.10
Brinell No.	197	197	241

In each case the two rubbing specimens were cut from the same block, *i.e.*, the test was of No. 1 iron rubbing on No. 1 iron, No. 2 on No. 2, etc. The tests were carried out at room temperature and no lubricant was employed. In all three cases the preliminary running in has been ignored, the loss-of-weight figures being reckoned only after the specimens were bearing all over their surface.

The average speed of the machine was 240 revs. per minute; each rev. equals one double stroke of 8 in., hence the average superficial speed was 160 ft. per minute. The load throughout all the tests was 47 lbs. per sq. in. Only the small stationary specimen was weighed.

The total loss in weight of the three different irons after 250,000 double strokes was:—No. 1, 3.3 gms.; No. 2, 2.75 gms.; and No. 3, 2.2 gms. Low total carbon iron will undoubtedly come into its own before many more years have past. There has long been what is termed semi-steel, but, properly melted, low total-carbon iron is something better.

Desulphurising Cast Iron.

The process of desulphurising cast iron has been considerably improved during the last few years. The best way of desulphurising cast iron is in the receiver of the cupola, wherever it is possible, and by means of attaching one of the patent apparatus now on the market, one then obtains the iron quite free from slag. By these methods the slag formed during the melt is prevented from running into the receiver, by means of a slag-collector, so that the iron as it is melted is separated from the slag, and therefore in the best condition for adding desulphurisation blocks or powders.

Entirely wrong impressions regarding the chemical reaction of earth alkalies with the bath of molten metal are prevalent among foundries in general. The chemical process and the fact that refined, compact iron is obtained with 80 per cent. scrap and 20 per cent. pig-iron can be explained in the following way:—

Molten iron contains sulphur combinations not only in the form of gases, but also in solution, that is to say, neither chemically bound nor gaseous;

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similarly iron-oxygen combinations are present. Silicon, in the form of silicic acid emulsions, is also present. All these inclusions cause hard places, funnels and segregation in the solidified castings.

When the earth alkalies are brought into contact with the iron mass, a violent reaction takes place with the result that sulphur is not only expelled in combination, but the harmful inclusions, being specifically lighter, are driven upwards. The very thin liquid desulphurising slag produced by the earth alkalies prevents the formation of an oxide layer, but allows the gases to pass out.

Metallurgical Standardisation in the Foundry.

The war proved to all foundrymen that the metallurgist was essential to the foundry plant, just as sand is to the moulder. Previous to the year 1914 metallurgical and engineering chemistry were to a great extent ignored in this country by foundrymen, and it is only during the last few years that it has approached its zenith, although there is still some doubt left in various works of the assistance the laboratory renders to the foundry. Usually the duties of the metallurgical chemist cover a wide field, and the following are some of the subjects he has to include in his daily task of prime import: (1) Research work and investigations for the benefit of the works; (2) mechanical testing; (3) metallography; (4) chemical analysis.

Standardisation should be the metallurgist's chief aim, and the foundry should have the full attention of the laboratory as it is the most important shop in any works feeding the other departments. Some foundries use only a few different brands of pig-iron, others up to twenty to thirty kinds, but in any case the contents of every truck of pig-iron that comes into the railway siding should be chemically analysed, and the correct way of obtaining a uniform result is by taking, say, six fractures out of each truck and drilling in each in various parts. The result should be recorded on a chart with delivery table, and any other details relating to the pig-iron. The same procedure should be observed with deliveries of coke, and the chief point in this is sulphur which should not be more than 0.800 per cent. and mineral matter from 7 to 10 per cent. Other material used, such as limestone, ganister, clay, and sand for moulding, should receive an occasional analysis.

The number of iron mixtures vary with the class of work, but a moderate iron foundry will have from four to six in use. A sample of these mixtures should be analysed, and also mechanical tests made regularly, at least once a fortnight. Should these tests vary whilst the chemical composition remains approximately constant, microscopical examination should be made.

For example, the tensile stress varies with the size and shape of the graphite grain. Small rounded particles conduce to high-tensile and elongated curved plates to low-tensile. The structure of the graphite depends chiefly upon the rate of solidification and further cooling; very slow solidification promoting the formation of large curved plates which reduce the ductility and strength of the metal.

Standardisation in the steel foundry is not only beneficial but essential, and the procedure depends upon the type of furnace used. In the case of crucible process for the manufacture of steel castings, every consignment of raw material such as steel punchings and other steel scrap should be analysed and results duly recorded on charts similar to those used in the iron foundry. Also, the contents of the ferro alloys used should be determined and registered in the same way. The final product should receive regular attention and be analysed and subjected to full mechanical tests at least twice a week.

With other processes for the manufacture of steel castings such as the electric furnace, and Bessemer, the pass tests and final tests, and the analyses of slags should be recorded, and as many details as possible of every heat should be kept.

In the manufacture of malleable cast iron the preservation of data obtained as suggested will prove of immense value, and form an admirable guide for further improvements. The cost of adopting science in the foundry is comparatively small when the valuable data obtained is considered, providing, of course, science is correctly adopted.

Moulding and Core Troubles in the Foundry.

The foundryman is continually searching for the causes of scrap castings, and during the past few years he has been materially assisted by the scientific investigators. Research work has recently centred on moulding sands, and whilst the subject has only been touched on the surface, much valuable information has been obtained respecting porosity, refractoriness, and that very peculiar property of bond. These particular properties have been dealt with very extensively, and the knowledge obtained must have satisfactorily cleared up some waster problems.

Some troubles, as blowholes, scabs, rough spots, hot cracks, warps, strains and veins, set the average man thinking about his moulding, his sand, and his metal, but generally, provided it is not an obvious core trouble, he will not look to this latter direction for the cause. Every foundryman has had trouble with cores at one time or another, and when the matter has been righted, and he gets a spell of good luck, he is apt to consider that he will now be immune from faults from cores. It is exceedingly difficult to control core making so that results shall be uniformly good, and it is the author's experience that lack of uniformity in the quality of cores is the cause of numerous wasters, which are usually put down to bad metal or faulty moulding.

An automobile differential casing suddenly developed blowholes in a flange on the dome portion. The cores were vented exactly as usual, and were made from the same sands in the same way, but investigation showed that the sands were mixed in a heap some time before use, and that when used in dry weather there was a tendency for the finer sands to slide to the bottom, and their use resulted in a harder and more compact core.

The mixing of core sands should be as perfect as possible, as different grades of sands, if lying in patches, will often cause rough spots, veins and scabs. Cracks and pulls have been found due to the oil used. It is evident that certain blends of oil are better suited than others for certain sands.

Also, if the oil is not of the right character, when the hot metal comes into contact with the cores, the binder does not burn off quickly, and the core remains strong long enough to cause a strain or crack.

The baking of oil sand cores is not as simple a matter as is usually supposed, because the core comes from the oven strong it must not be assumed that it is all it should be. Not only must the temperature of the oven be uniform but the admission of air should be as closely the same as possible. The baking of an oil core is a case of not only drying but chemical action. The air has an oxidising effect on the oil, and if the oil has not had enough oxygen the core will be weak, giving rise to buckles. The same insufficient supply of air will leave a much greater volume of gas to be expelled from the core when the mould is cast, causing blowholes. There are products now on the market which are capable of remedying insufficient oxidation in baking, reducing very considerably the amount of gas evolved on casting. Oils can be obtained which will mix with water, so that when the core is baked there is less organic matter left to be evolved as gas on castings.

These cores have now a wide sphere of utility, and the maker of light, intricate castings, such as for the automobile industry, would wonder how he could get on without them. It is such manufacturers as these, having the most difficult castings to make, and the most difficult metals to handle, who find such a big field of subjects to put the blame of their wasters upon that they are apt to give their cores but scant attention. In most large foundries, casting light intricate work, there is a large core shop, generally presided over by a foreman who has nothing to do with the casting, and who attempts to lay the blame of wasters on the foundry foreman.

Tests should be frequently made on oil-sand cores, and a simple test is to take a 12-in. × 1 in. oil-sand core, put on 8-in. centres, and hang a small bucket in the centre, filling up with sand gradually. After the core has broken, weigh the bucket and sand, the weight being noted for future reference. Another simple test is to take a 1-in. cube of oil-sand core and take compression tests, the weight again being noted.

Spiral Bricks for Hot-Blast Stoves.

By J. Tornblad.

When designing hot-blast stoves for blast furnaces the present practice is to construct them with a detached shaft filled with regular horizontal layers of chequer bricks arranged to form a number of perpendicular straight flues for the passage of the hot gases and the blast. When using uncleaned furnace gas for the heating of the stoves, the chequerwork has to be very carefully designed, so that the flues can be cleaned from time to time; and for this reason the sectional areas of the flues have to be comparatively large. To increase the efficiency of the stoves, the flues in the chequerwork have to be reduced in size, with the result that it becomes difficult to clean them effectively, and to obviate this difficulty, such stoves have to be heated with cleaned blast-furnace gas.

Disadvantages of Chequerwork.

This arrangement of the chequerwork has the following disadvantages:—(1) Great weight of the chequerwork in relation to its heating surface. With a weight of from 60 to 70 lbs. per cub. ft. of chequers, the corresponding heating surface only amounts to from 3 to 4.5 sq. ft. (2) A large proportion of the chequerwork takes no active part in the storage of heat, as large portions of it overlap each other and therefore do not come in contact with the hot gases and the blast to be heated. These ineffective portions of the chequerwork amount to from 21.5 to 66.5 per cent. of the total mass in the stove. (3) By the alternate expansion and contraction of the solidly built-up chequerwork, the lining as well as the casing of the stove are subjected to injurious strains, and the whole stove to premature destruction.

As the practice of firing hot-blast stoves with cleaned blast-furnace gradually became more adopted and the necessity for the periodical cleaning of the chequerwork flues was thus eliminated, there was no longer any reason why these flues should be made exactly vertical and with smooth walls. Opportunity was therefore provided for replacing the geometrically built-up chequerwork with other types of bricks, designed to absorb more fully the heat from the hot gases and subsequently to give off this stored heat to the blast. New shapes of bricks have therefore been designed which, in contrast to the usual system of building them up as chequerwork, are piled up in irregular heaps in the stoves.

Semmel Bricks.

The best-known type hitherto of such new kind of refractory bricks are the so-called "Semmel" bricks. There are certain weak points of these Semmel bricks, however, which may be noted:—(1) Owing to their shape and size, they pack together very closely in the stove, and thereby obstruct the passage of the hot gases and the blast. With natural chimney draft, the maximum depth of a heap of Semmel bricks that can be used is only about 15 ft. (2) The bricks do not uniformly absorb the heat, as the thinner parts of them are too rapidly heated, while the thicker parts are not sufficiently heated and therefore do not take part in the heat storage to their full capacity. The holes or "flues" in the chequerwork only function properly when the bricks are in a vertical position; when they are tilted, or lying flat, the hot gases as well as the blast only partly pass through the holes in the bricks. (3) Practically the whole of the heat absorption takes place in a comparatively low heap of these bricks, while the remainder of the chequerwork remains relatively inactive. (4) The bricks are not free to expand and contract, and therefore act in the same way as ordinary chequerwork on the shell and lining of the stove.

Hartmann Bricks.

To obviate these disadvantages as far as possible, an entirely different type of chequer bricks has been evolved, namely, the so-called "spiral" bricks (Hartmann patents) which, after extensive tests and practical experience are now manufactured in the following three sizes:—

No. 1 Bricks.—Overall length, 16 in. (3 windings), overall diam., 7⅛ in.; diam. of spiral winding, 2 $\frac{9}{16}$-in.; weight of brick, 16.83 lbs.; heating surface of brick, 2.85 sq. ft.; number of bricks per cub. yard of chequerwork, 71.

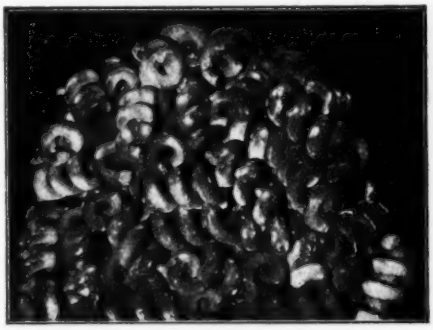
No. 2 Bricks.—Overall length, 14½ in. (3 windings); overall diam., 7⅛ in.; diam. of spiral winding 2¾ in.; weight of brick, 18.52 lbs.; heating surface, 2.85 sq. ft.; number per cub. yard of chequerwork, 73.

No. 3 Bricks.—Overall length, 13¾ in. (2½ windings); overall diam., 8¾ in.; diam. of spiral winding, 3⅜-in.; weight of brick, 25.85 lbs.; heating surface, 3.32 sq. ft.; number per cub. yard of chequerwork, 58.

Advantages of Spiral Bricks.

The advantages claimed for the spiral bricks are:—(1) Every part of its surface partakes equally in the heat storage, as the section of the brick is the same throughout and the surface throughout is uniformly exposed to the action of the hot gases and the blast. The surface contacts are a minimum, as the bricks only touch each other at three points at the most. There are no holes or flues in which the hot gases or blast can be trapped.

(2) The surface area of the bricks is comparatively large. Through the open centre and spaces between the spirals the greatest part of the surface is exposed to the action of the hot gases and the blast, and as a result of their round shape the bricks, no matter in what position they are, offer very little resistance to the flow of the hot gases and the blast. From actual tests in hot-blast stoves it has been found that with a heap of spiral bricks, 43 ft. 6 in. high, the loss of suction only amounted to 20 per cent. as against 50 per cent. through a heap of Semmel bricks only 18 ft. high.



SPIRAL BRICKS FOR HOT STOVES.

(3) The weight of bricks per unit volume of chequerwork, as compared with other types of bricks, is considerably less, and due to the special shape of the bricks and the relatively small thickness of the spiral windings, the mass of the bricks is ample to absorb satisfactorily and give off readily large quantities of heat.

(4) A special advantage, due to the spiral shape of the bricks, is that the hot gases and the blast are both given a swirling motion, thereby enabling the gases to give off effectively their heat and the blast to absorb effectively the heat from the bricks. One effect of this swirling motion is to reduce friction of the gas and blast respectively. Moreover the hot gases and blast do not pass parallel with the surfaces of the bricks, but strike them at an angle of from 65 to 90 deg.; thus the heat is most effectively exchanged.

(5) The spiral bricks withstand the pressure due to the weight of a deep heap of them, as well as the stresses set up in the bricks by the change of temperature. The shape of the bricks causes them to form natural vaults throughout the chequerwork, which relieves the bricks from any

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considerable pressure in the lowest part of the heap. The ends of the bricks being free, there is nothing to prevent them from expanding or contracting.

By using different sizes of bricks, their efficiency is utilised to the maximum of their capacity. The top of the heap in a hot-blast stove is composed of No. 3 spiral bricks, which have the largest mass and a correspondingly large heating surface. The middle portion of the heap is composed of No. 2 bricks, with the largest heating surface per unit volume of chequerwork, and medium mass. Finally the bottom of the heap is made up of No. 1 bricks, with the least mass, but nearly the same heating surface per unit of volume of chequerwork as the No. 2 bricks. By this arrangement the most satisfactory absorption of the heat from the hot gases is effected, as well as the giving off of the stored heat to the blast.

The following are the results obtained at the Ilsede Ironworks, Grossilsede, Germany, before and after the hot-blast stoves were partly filled with Hartmann spiral bricks. The stoves were 95 ft. high, and 21 ft. 6 in. outside dia. of the casing. The stoves were previously filled with ordinary chequer bricks. The total height of the chequerwork was 72 ft., with flue openings measuring 7½ × 7½ in. The results obtained with these stoves were as follows:—

Total heating surface of stove, including lining, etc., 49,392 sq. ft.

Gas consumption per hour, 338,880 cub. ft., equal to 31 per cent. of the total from the blast furnace, with three stoves in use.

Efficiency of stove, 54.3 per cent.

Loss of heat in the waste gases, 36.0 per cent.

Loss of heat from radiation, 9.7 per cent.

Temperature of waste gases (mean), 480 deg. C.

Temperature of hot blast (mean), 780 deg. C.

After the change-over, when 49 ft. 3 in. of the original chequerwork was taken out of the stoves and replaced with three strata of Hartmann spiral bricks, of the following thicknesses: 13 ft. 2 in. of No. 1 bricks, 19 ft. 8 in. of No. 2 bricks, and 16 ft. 5 in. of No. 3 bricks, the following results were obtained:—

Total heating surface of stove—including common chequer bricks, spiral bricks, brick lining, etc., 84,636 sq. ft.

Gas consumption per hour, 234,750 cub. ft., equal to 20.9 per cent. of the total from the blast furnace, with three stoves in use.

Efficiency of stove, 78.5 per cent.

Loss of heat in the waste gases, 7.4 per cent.

Loss of heat from radiation, 14.1 per cent.

Temperature of waste gases (mean), 120 deg. C.

Temperature of hot blast (mean), 770 deg. C.

The increase in the loss of heat from radiation was due to the fact that in this latter instance the stoves were run very hot, by burning the maximum quantity of gas. The stoves were in no way insulated. Had they been so, the radiation losses would of course have been much less, with a correspondingly increased efficiency of the stoves.

The figures show how the efficiency of existing hot-blast stoves could be considerably increased, simply by substituting part of the old chequerwork with spiral bricks.

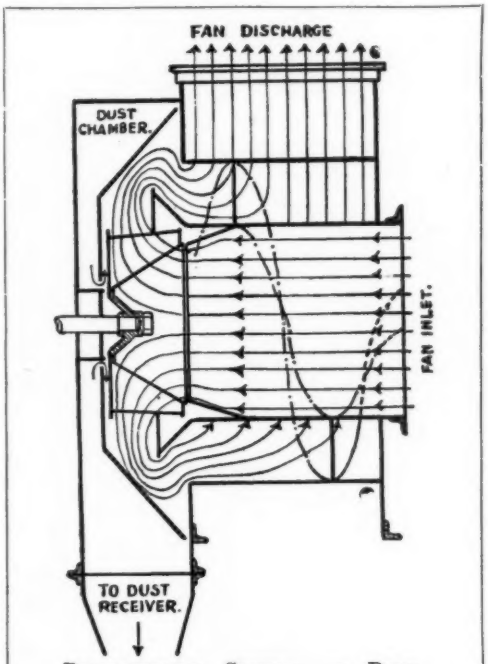
Further, when it is a question of installing new stoves to be partly filled with Hartmann spiral bricks, such stoves can be made much smaller with consequent reduction in cost, and yet such stoves would be as efficient and even more so than the present large and more expensive stoves filled entirely with ordinary chequer bricks.

As the spiral bricks are put in the stoves in natural irregular heaps, without any setting whatsoever, there is a considerable saving in time and labour in filling a stove partly with them as compared with filling the same stove entirely with ordinary chequer bricks. No expert bricklayers are required; the work of throwing the spiral bricks into the stoves can be done by any ordinary labourer, as the bricks are allowed to pile up on top of each other in the stove as they drop down.

Alpha Electric Welding Company, Limited.—Capital £1,000 in £1 shares. Directors: F. A. Saunders, 55, Lambert Street, Newport, Mon.; and F. Pinnett, Chaseley, Alteryn Avenue, Newport, Mon.

"Keith-Blackman" Dust-Separator Fan.

This device, which has been devised by Messrs. James Keith, Blackman Company, Limited, 27, Farringdon Avenue, London, E.C.4, combines in one compact unit a centrifugal fan and a centrifugal dust settler. Primarily evolved to meet the increasing demand for flue-dust and grit arresters in connection with induced-draft fans for boilers, this separator fan may be employed for collecting any dry non-clogging dust if local conditions permit of the dust being collected near the point chosen for the fan. The principle of centrifugal separation is employed in all the various forms of "cyclone" dust collectors, but in this dust-separator fan, advantage has been taken of the fact that, under any normal working conditions, the whirl set up by the runner is considerably faster than that produced in any "cyclone"; and, by using the momentum energy of the dust particles without disturbing the continuity of air flow, a high efficiency of dust separation is obtained at relatively little sacrifice of the manometric and mechanical efficiencies of the fan.



DIAGRAMMATIC SECTION OF DUST-SEPARATOR FAN.

The dust-laden flue gases (or air) are inducted through the circular inlet duct to the eye of the fan runner, at which point the flow is diverted by the runner from an axial to a radial direction. This change of direction is the first step toward the final separation of the dust, inasmuch as the particles tend to pass toward the backplate of the runner, along which they slide, impelled by the vanes. On reaching the periphery of the runner the dust is projected, under centrifugal action, on to the smooth slope of the deflecting cone, along which it is conducted, until, on reaching the corner formed with the casing side-plate, the dust is carried through the narrow annular space at this point into the surrounding dust chamber, assisted by a slight air current operating on a closed air circuit.

Whilst the dust is conducted centrifugally to the dust chamber—falling into the hopper at the bottom of same, and thence to any convenient receptacle—the main delivery stream of gases or air (still retaining its rotational energy) escapes into an annular helical diffuser around the outside of the inlet duct, and so, by a suitable connection, to the chimney or atmosphere, as the case may be. When using samples of boiler flue dust in a demonstration dust-arresting fan installed at the maker's works the proportion thus recovered is no less than 97 to 98 per cent.

The Influence of Oxidation Processes in the Blast Furnace.*

Neither oxidation nor reduction is continuous in the greater number of iron-smelting processes. Secondary reactions take place as a rule; their effect on the quality of the product and on its economical production require the closest attention on the part of the smelter.

In the old Catalan hearth the air had to pass through a thick layer of glowing charcoal before reaching the ore. Alternate layers of small lumps of ore and charcoal covered the mouth of the tuyère. The carbon dioxide formed in front of the tuyère was immediately reduced to monoxide. The ore, surrounded as it was by an exclusively reducing medium, was de-oxidised to a spongy iron which rapidly absorbed carbon. But the small lumps of ore, mixed with charcoal and pounded solid placed above the orifice of the tuyère, escaped in greater part from the influence of the blast. The iron merely melted without being reduced, and accumulated in the lower part of the hearth, where it decarburised to spongy iron. By judiciously proportioning the quantity of small ore, the furnace could be made to produce at will

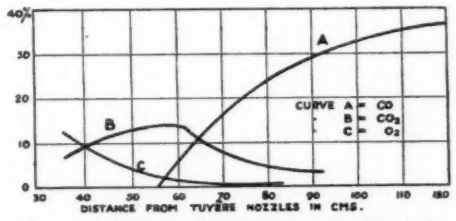


FIG. 1.—VOLUME PERCENTAGES OF CO, CO_2 AND O_2 AT DIFFERENT DISTANCES FROM THE TUYERE NOZZLES.
Results of Van Vloten's Experiments.

mild, fibrous iron or steel, if little or no ore was used or any intermediate quality. The refining action—that is, the oxidation of the carbon—could only be obtained with a liquid ferruginous slag, which acted not on the iron itself, but on the material associated with it. During the whole course of the process the spongy iron was surrounded by an atmosphere of neutral gas, which prevented any re-oxidation. No noxious reaction, no reversal of the process, could take place, and the productive capacity of the furnace per unit of cubic capacity was very high—about double that of the modern blast furnace.

In the finery hearth, which differed but little structurally from the bloomery, the charcoal was used in large lumps, heaped up loosely and not pounded. The broken pig-iron was kept at about 7 in. to 8 in. From the tuyère-plate it was melted under the influence of an oxidising flame. The molten iron dropped through the hot, loose charcoal lumps, was oxidised and gathered as wrought iron in the lower part of the furnace.

The two processes may be compared as follows:—

	Catalan hearth.	Finery hearth.
Solid phase	Reducing	Reducing
Gas phase	Reducing	Oxidising
Final result... ...	Reduction	Oxidation

The comparison seems to point to the preponderating influence of the gas phase.

In the blast furnace the hearth and the lower part of the bosh are full of more or less large lumps of coke. The iron, reduced in the upper part of the furnace, carburised, and more or less combined with foreign substances, melts at a certain height above the tuyères, and finds its way, in the form of drops, through the interstices between the lumps of coke, to the liquid metal accumulated in the hearth. The path of the drops of iron is in all cases sinuous, and their progress down to the level of the tuyères slow; the same may be said also of the liquid slag which accompanies them. Both drops of iron and of slag come successively within the influence of the solid phase when in contact with the coke and that of the gas phase in front of the tuyères. The coke may carburise whatever iron has not yet reached the point of saturation in this respect, and should the slag contain (which normally it should not) ferrous-oxide compounds, these will be reduced. The effect of the solid phase consists in the carburisation of the raw iron, and eventually in the reduction of the ferrous constituents of the slag.

The effect of the gas phase at the tuyère level depends largely on the density and more or less porous nature of the coke. These are conditions which affect the rapidity with which the carbon dioxide, formed at first by the contact of the incoming air with the hot coke, is reduced to monoxide. The smaller and denser the coke and the higher the temperature, the more rapidly this transformation takes place, and also the dissociation of the watery vapour brought in with the blast.

Thus we have in front of each tuyère a volume of gaseous mixture of free oxygen + CO_2 + H_2O, whereas at the centre of the hearth we have only CO + N. About the extent in both a vertical and a horizontal direction of the oxidising gas phase we know at present nothing, but we may be certain that it has practically no oxidising effect on the liquid slag, which, being mainly composed of calcareous clay silicates, can suffer no alteration from the action of oxidising gases. These latter, on the contrary, have a powerful refining effect on the drops of liquid iron, counteracted to a certain extent by the white-hot coke, but not so much as to prevent the formation of a certain quantity of ferrous oxide, which is absorbed by the slag. The slag in its turn acts on the liquid iron in the same way as the additions of ore in the open-hearth furnace. All the foreign substances in the iron bath tend, according to the prevailing temperature and its degree of concentration, to decompose the ferrous oxide. With the high temperatures in coke furnaces the carbon is the principal active agent, while such low temperatures as prevail in charcoal furnaces are more favourable to the action of the silicon and manganese, and for this reason such furnaces are not suitable for producing iron high in either of these two elements. The blast furnace therefore must partly perform double work. The iron already reduced in the shaft is re-oxidised at the tuyères, and must again be reduced in the hearth. Furthermore, the chemical energy spent in the shaft for the reduction of the silicon, manganese and phosphorus, is partly lost, as the oxidation of the iron at the tuyères drives these elements into the slag. It is evident that these reactions must be detrimental to the productive capacity of the furnace. When originally published (in 1910) the author's views on these reactions at the tuyères were partly rejected and partly ignored. They, however, had already been established in 1895, by certain experiments of Van Vloten, of which the results are shown in Fig. 1. It will be seen by these that free oxygen exists in the hearth gases, up to a distance of 60 cm. (24 in.) from the tuyère-nozzles, and carbon dioxide is still to be found as far as 90 cm. (36 in.) from the same point, whereas no carbon monoxide is to be found at a less distance than 55 cm. (22 in.); this gas is first found in considerable quantities only when the dioxide has practically disappeared, as shown by the curves in the diagram.

More recently (in 1923 and 1925) Perrott and Kinney made for the U.S. Bureau of Mines a number of experiments on large modern blast furnaces (10 furnaces in 1923 and two in 1925), with hearths from 15 to 19 ft. in diameter. The results (Figs. 2 and 3) were, on the whole, similar to those obtained by Van Vloten. Free oxygen was found as far as 60 and 70 cm. (24 and

* Summarised by H. Savage (Seraing, Belgium), from an article by Fr. Wüst in "Stahl u. Eisen."

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28 in.), respectively, and carbon dioxide up to 1 m. (40 in.) from the nozzles. The additional fact was also established that variations in the blast-pressure (one atmosphere and ¼ atmosphere=14.70 lbs. and 3.675 lbs. per sq. in.) had little or no influence whatever on the oxygen or the carbon dioxide.

But the existence of an oxidising gas phase at the tuyères of the furnace as disclosed by the U.S. Bureau's experiments can be proved mathematically also. All the carbon meeting the air at the tuyeres is transformed either to carbon dioxide or to carbon monoxide. In neither case is the ratio of the nitrogen to the oxygen affected in the slightest degree. If there are in the air 265 units of volume of oxygen to 1,000 units of nitrogen any loss of oxygen at the tuyeres can only be due to the combination of a portion of it with the liquid iron, provided it was only the carbon that combined with the oxygen. If, on the other hand, the proportion of oxygen to nitrogen is above the atmospheric ratio, it can only be due to a refining action—that is, an exchange between the ferrous oxide of the slag and the carbon in the iron bath.

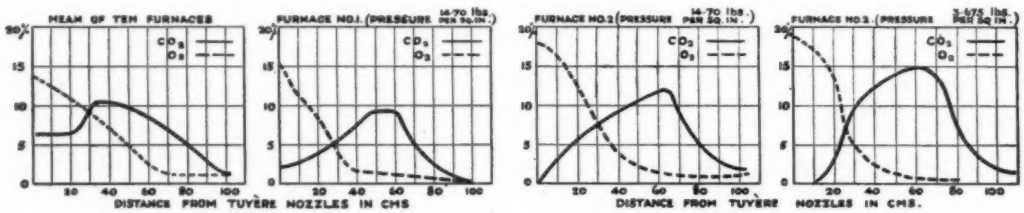
MEAN OF TEN FURNACES
FURNACE NO.1. (PRESSURE 14·70 lbs. PER SQ. IN.)
FURNACE NO.2 (PRESSURE 14·70 lbs. PER SQ. IN.)
FURNACE NO.2. (PRESSURE 3·675 lbs. PER SQ. IN.)
CO_2
O_2
DISTANCE FROM TUYÈRE NOZZLES IN CMS.

FIG. 2. FIG. 3.

RESULTS GIVEN BY THE U.S. BUREAU OF MINES.

Iron Oxidised at the Tuyères.

The exact amount of oxygen taken up by the iron in front of the tuyeres is difficult to determine. Gillhausen found by experiments carried out on four furnaces an average of 3,076 cub. m. of blast, containing 642.9 cub. m. of oxygen at the volume required for the production of one metric ton of pig-iron. Van Vloten, after analysing a number of samples of hearth gases, found 35 which were low in oxygen by from 1.1 to 23 per cent. (the average being 11.77 per cent.). Ten other samples showed surplus oxygen, to the extent, in one case, of 58.9 per cent., the average in this case being 18.3 per cent. Taking 642.9 cub. m. of oxygen as the necessary volume for the production of one ton of iron, 11.77 per cent. of that quantity = 75.67 cub. m., represents the loss due to the formation of ferrous oxide, that is the oxidation of 378.7 kg. of iron per 1,000 kg. of pig-iron produced. Excesses of oxygen in the hearth gases in front of the tuyères can only result from the decomposition of the ferrous oxide in the slag. No oxygen combined in the hearth with sulphur, silicon or manganese ever reappears in the gas phase.

From the results of the researches by Perrott and Kinney as to the ratio of oxygen to nitrogen in the gases in the hearth, Herr Wüst reaches the conclusion that the quantity of iron oxidised at the tuyères averages about 350 kg. per 1,000 kg. The excess of oxygen towards the centre of the hearth is, however, often very great. Thus Perrott and Kinney found at the centre of the hearth an increase of 106.6 per cent. in the oxygen which, according to Herr Wüst's calculations, would correspond to 3,430 kg. of iron. This is of course impossible, but the fundamental error is easily located. The motion of the current of gases over the whole surface of the hearth is by no means uniform; towards the centre there appears to be a more or less motionless layer of gas in which carbon monoxide accumulates. As proved by the experiments the blast does not seem to penetrate more than 1 m. (40 in.) into the hearth, and rises at the edge of the furnace. Finally there is the possibility that the drops of iron passing before the tuyère nozzles are driven by the blast towards the centre of the hearth, where they are taken up by the slag, making it richer in ferrous oxide which in turn explains the high content of carbon monoxide in the gases. This was found by Perrott and Kinney to be as much as 70 per cent. CO at the centre of the hearth, when theoretically there should have been no more than 34.7 per cent. of monoxide. It follows that the increased percentage of oxygen in the gases at the centre of the hearth cannot be taken as the basis for calculating the quantity of the oxidised iron, and further, that the formerly accepted hypothesis of an equally effective combustion over the whole surface of the hearth is not consistent with the facts.

The re-oxidation of the iron in front of the tuyères is thus of a wholly unexpected importance, and it seems probable that in the earlier cold-blast furnaces its effect must have been sufficient to annul completely the reducing work done in the shaft and bosh. The surprising results attained by the use of hot blast and more recently of dried air are, in point of fact, due to a diminution in the oxidation zone in front of the tuyères.

It is a well-known fact that the reduction of ferrous oxide by carbon is a direct reduction, that is an endothermic process absorbing 830 calories per kg. of iron. Heat is therefore consumed below the tuyere level, and it might be urged that the molten iron might be so much cooled down as to solidify and block up the whole hearth. But on consideration it will be found that this cannot occur. The heat due to the oxidation of 1 kg. of iron before the tuyères is equivalent to that obtained by turning 0.214 kg. of carbon into carbon monoxide, say, 0.214 × 2,430 = 520 kg. calories. Thus for each per cent. of iron thus oxidised the temperature of the iron bath is raised by $\frac{520}{0.2\times100}$ = 26 deg. C., and for 20 per cent. minimum of iron, the total rise in temperature would be about 500 deg. C. Some of this heat, be it remembered, is absorbed by the slag. At any rate there can be no question of any solidifying of the bath, except perhaps immediately after a tapping, when any liquid iron, which might remain in the hearth, might be so far reduced in carbon by the action of the ferrous oxide in the slag as to solidify and become wrought iron. Some such action is no doubt the cause of " bears " formed at the bottom of the furnace.

In the case of a hearth completely filled with pig-iron conditions differ totally. The temperature may rise to such a point that a portion of the iron may actually volatilise, and be carried upwards with the ascending current of gas in a finely divided form. It is the cause of the pyrophoric properties of the dust deposited near the furnace-throat, and is accompanied by manganese vapours. Water-cooling of the hearth becomes necessary in consequence of the high temperature of the iron in the hearth, in marked contradistinction to what takes place in mixers, which hold masses of liquid iron 10 to 40 times greater, and yet require no water cooling with little or no danger of a piercing of the refractory lining, although this of less thickness than in the case of the blast furnace.

Suggested Ameliorations.

From what precedes, there can be no escaping from the conclusion that, in the usual blast-furnace practice, a considerable hitherto unsuspected portion of the iron already reduced, is re-oxidised to an extent which must seriously prejudice the economy of the process. To minimise such re-oxidation it becomes necessary to restrict, as far as possible, the extent of the oxidising zone in front of the tuyeres. This may be effected in various ways, as for instance by the use of hot and dry blast, or of oxygenated air, or by increasing the temperature of the blast, but perhaps still

more efficiently by enlarging the width of the hearth.

Herr Wüst next compares the extent of the oxidising zone in three furnaces, with hearths respectively 3 m., 4.5 m., and 6 m. (10 ft., 15 ft. and 20 ft.) in diameter. In the first case the oxidising zone represents 90 per cent. of the surface of the hearth; in the second case 68 per cent., and in the third case 55 per cent. only. The wider the hearth the more economical should be the working of the furnace.

Influence of Wider Hearths.

From information supplied by different firms who had carried out alterations in their blast furnaces, the author is able to show that an increased horizontal cross section of the hearth had always the effect of increasing the output per unit of capacity of the furnace, the coke consumption being at the same time reduced considerably except in a solitary instance. But even after such an increase in the hearth diameter, the daily output of iron only averaged about 1 ton per cub. m. of hearth capacity in 24 hours—much below that of the bloomery or Catalan hearth, in which the production figure reaches 2.4 tons per day per cub. m. of capacity.

The beneficial effect of wider hearths has often been attributed to another cause, namely, increased volume of blast. This is of advantage in itself, no doubt, but the tables compiled by the author show that the increased output of furnaces which have been altered is always greater in proportion than the increase in the volume of the blast per unit of hearth capacity. Moreover, the lower consumption of coke per ton of iron produced proves that it is not the effect of purely physical causes, which lead to a higher output, but that changed metallurgical conditions, more particularly the restricted oxidation zone in the hearth, also play an important part.

The full advantage of wider hearths, however, can only be realised if the volume of the blast is increased in a greater ratio than the size of the hearth. The influence of the blast, as a matter of fact, is restricted to the oxidising zone, which in ordinary furnaces occupies about half the section of the hearth. The consequence is that to obtain the best results from an increase in the diameter of the hearth, the furnace must be driven harder than it was before such increase.

Wide hearths, on the other hand, give a much larger cooling surface than narrow ones, just at that part of the furnace, too, where the highest temperature is reached. An increase in diameter from 4 m. to 5 m. (13 to 17 ft.) may give as much as 125 per cent. more cooling surface. The water used for cooling also carries off in proportion more heat from the wide hearths than from the narrow hearth. This, again, is a condition which must be met by a harder driving of the furnace if any advantage is to be gained.

Narrow hearths, as in the past, mean a more restricted surface of contact between the ferruginous slag and the liquid iron. The result is a very slow reduction of the ferrous oxide in the slag, and if any attempt is made to quicken unduly the reaction by forcing the blast, this may lead to cold-working. Now cold-working is not, as is sometimes supposed, the consequence of the ore arriving in the hearth unreduced—an impossible thing after an exposure for hours to a reducing atmosphere at a high atmosphere. Cold-working is due to the fact that enough time has not been allowed, and a sufficiently high temperature has not been reached, to secure the decomposition of the ferrous oxide in the slag. With a wider hearth and a smaller oxidising zone, less iron is absorbed by the slag, and owing to the larger surface of contact between the liquid iron and the slag, the refining action is much more rapid.

Internal Movement.

Further improvements can easily be effected in the design and the working of blast furnaces. The effect of the oxidising zone may be materially reduced by not allowing the descending drops of iron to pass through it, but by restricting their passage to the hearth principally to the central neutral phase. Boshless furnaces would certainly give better results than the usual profiles, and even more might be expected from furnaces of a greater diameter at the hearth than at the throat.

In the downward movement of the burden the coke, by reason of its smaller specific gravity, is driven outwards against the walls of the furnace, while the heavier materials, the ore and limestone, concentrate towards the middle. At the level of the tuyères only coke will be found, whereas the remainder of the burden melts some 7 or 10 ft. higher up in the furnace, the greater part—if not the whole of it—in the neutral gas zone of the hearth, and is scarcely met by the entering blast or the column of carbon dioxide resulting therefrom. It is to be expected, however, that precisely this current of air would find its way upwards, not through the whole burden, but through the surrounding coke. This question, however, can only be settled by experiment.

It may be recalled in this connection that bloomery hearths of a profile similar to that suggested in this Paper have existed for centuries past. In these old hearths the diameter of the hearth was often from two to three times the size of that at the throat. The bloom gradually formed at the bottom of the hearth, was scarcely touched by the blast, and there was very little loss by combustion.

The erroneous assumption that combustion must take place uniformly all over the whole surface of the hearth has led to the tuyères being placed radially and pointing towards the centre of the hearth. This arrangement is precisely the one which gives the largest possible oxidising zone. By arranging the tuyères tangentially, the extent of this objectionable zone would be much reduced and better working results obtained. The author has applied for German patent rights for this arrangement. At the same time the furnace may be made cylindrical, or even of the form of a truncated cone, which would lead to further improvement.

Keighley Students Visit Sheffield.

On Tuesday, March 22, a party of 25 students of the Keighley Technical College, attending metallurgy classes at the Keighley Laboratories, Limited, paid a visit to the steel works of Messrs. Sanderson, Bros. & Newbould, Limited, of Sheffield.

The party arrived at 10.30 a.m., and were met by members of the management and staff. The morning was spent in the steel-melting department, where the entire process of crucible steel melting was clearly described by the steel-melting manager. The production of the gas and the making of clay crucibles were also inspected, and finally the actual pouring of high-speed steel ingots was seen.

The students were entertained at luncheon, presided over by MR. T. W. WILLIS, works director, who welcomed the students on behalf of the Chairman and Directors of the firm, and pointed out that the engineering industry could only develop on sound lines by steel users and steel makers appreciating each other's work and difficulties. The keystone of industrial development and prosperity was aptly described as "the more we are together."

MR. L. PICKUP, on behalf of Mr. Healey, the Principal of the Technical College, briefly responded, and proposed a vote of thanks to the Directors for their kindness in arranging such an interesting visit. MR. ALLEN BINNS, a student, seconded the proposal on behalf of the students.

CAPT. V. S. GOODYER, who organised the tour of inspection, briefly drew attention to the industries and engineering progress of Keighley.

Afterwards the party broke up into small groups, each of which was shown round the various departments, including heat treatment, rolling, file, saw and stainless steel, by members of the staff. The entire manufacture of all kinds of files, saws and knives was seen from the steel ingot to the finished article, packed ready for transport.

The precautions necessary to ensure the highest grade of such goods were pointed out and demonstrated; each was evidently the outcome of the 150 years' experience which this firm has had in the production of these high-class steel products.

After tea, the students were each presented with a souvenir made entirely from Messrs. Sanderson Bros. & Newbould's stainless steel—"Non-Stain 4,379."

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Discussion on Mr. D. F. Campbell's Paper on Electric Furnaces in Non-Ferrous Metallurgy.

This Paper, which was read at the annual general meeting of the Institute of Metals, was printed in a recent issue. It was announced that several corrections were to be made. These were:—

Page 211, col. 1, line 12—After "350 units per ton" insert "measured at the furnace terminals."

Page 211, col. 1, line 16—After "448 units per ton" insert "measured at the furnace terminals."

Page 211, col. 2, line 57 should read "efficiency of from 72 to 82 per cent., according to size and periodicity; the additional loss in the furnace. . . ."

Added Data Sought.

Dr. H. W. Brownsdon, referring to the table given in the Paper relating to an actual day's run in a 75-k.v.a. Ajax-Wyatt furnace on 61:39 brass, at Birmingham, in April, 1926, considered that in many ways the figures were rather abnormal than typical. The time interval between pouring and charging was not given, but he could not conceive of the two synchronising so completely that there was no interval of time between pouring and charging. The table showed that there were 13 heats in 11¼ hours. Also, the number of units consumed per ton of metal melted was extremely low, the average being 206, and he would like to know at what temperature the metal was poured; from time-temperature curves he had taken on the running of an Ajax-Wyatt furnace he had found that it required from 50 to 55 minutes to melt the metal, and then a certain amount of superheating was required; the superheating might be 100 deg. or so above the melting point of the metal. He could only conceive that the furnace working under the conditions indicated in the Paper was pouring what was called in practice the "cold" metal, and that the quality of the ingots would not be above suspicion. The conditions of melting, the form in which the metal was put into the pots, and so on, should be stated. Mr. Campbell was much more conservative when he had given a figure of 224 kw.-hrs. per ton for melting 60 : 40 brass for extrusion billets in a 600-lb. Ajax-Wyatt furnace; that was a very reasonable figure.

Metallic Losses.

A point in connection with melting practice which was always open to discussion was that of metal losses, and he saw no reason why this should not be cleared up once and for all. When referring to typical performances of Ajax-Wyatt furnaces in Birmingham, the author had stated that in nearly all cases there was a saving of at least 1 per cent. in the loss of zinc, though, it was pointed out, the methods of calculating losses varied. The statement that there was a saving of 1 per cent. might mean anything; it depended upon where one started from. In the best running conditions he had been able to experience—and they were somewhat special conditions—the loss had not been less than 1.1 per cent., and that was made up of practically 80 per cent. of zinc represented as oxide. When the whole of the recoverable metal had been extracted from the residue and returned to the furnace, one was still left with a residue equivalent to 1 per cent. of the metal put into the pot. That was exceptionally good running, but under average working conditions the loss came out at 1.3 per cent., of which about 1.1 per cent. was zinc oxide. These conditions were obtained when borax was used as a flux, but if borax were not used as a flux the 1.3 per cent. was increased to nearer 2 per cent., and under some working conditions it might easily be above that. A straightforward way to estimate loss was to regard the metal put into the furnace as 100, ascertain the weight of metal taken out as ingots and the residue left; that residue accounted for the loss, and one could easily determine what percentage was zinc and what percentage was irrecoverable metal. It must not be thought that, because the losses were reduced from 2 to 1.3 per cent. one had necessarily gained anything economically, because borax was an expensive flux, and the residue was so poor in metal that the refinery would not look at it. It was just as economical to use a flux such as salt in order to obtain a higher percentage of metal, so that it was not always that the most economical way of running a furnace was that which resulted in the least residue.

How Losses Occur and a Suggested Amelioration.

The metal loss appeared to occur in the early stages rather than in the later stages of melting. There was a residual amount of metal at the bottom of the bath after pouring, that metal being in the molten condition. Scrap was then added to the furnace, this being generally the first addition; the temperature fell, and there was a certain amount of material in the pasty stage. Inasmuch as the metal was heated from the bottom, the pasty stage was inclined to persist. It occurred to him that the Ajax-Wyatt furnace needed an arc at the top, because if there were more heat at the top, and the added scrap were melted more quickly, some of the difficulties might be overcome. Another point in connection with the Ajax-Wyatt furnace was that the oxide skimmed from the top of the bath represented only half the total losses. The walls of the furnace built up gradually, and periodically the material on the walls had to be removed; that material was equal to the amount of material skimmed off the surface of the metal. To his mind, that was connected with the material of which the lining of the furnace was made, because the same thing happened when the Ajax lining material was used as a feeder head for casting ingots.

Electric Heat-Treatment Furnaces.

The application of electric furnaces to the annealing of non-ferrous metals had been hopelessly neglected, and he considered that there was just as bright a future for their application to heat treatment and annealing as to melting. It must be appreciated that the Ajax-Northrup furnace was coming into favour because the Ajax-Wyatt would not do certain things. He had found it extremely difficult, even in the case of an Ajax-Wyatt furnace running on ordinary brass, to obtain satisfactory refractory linings, and he was sorry to say that the lining material he used came from America. Similar remarks applied to the adaptation of the Ajax-Wyatt furnace to the melting of the higher-melting-point alloys, in connection with which more research was needed. In annealing we could use electrical energy so economically that it would quickly displace solid, liquid or gaseous fuels. The whole of the energy, except that lost by radiation, could be absorbed into the material, given suitable design, and in an experimental furnace which he had running he had reached the point at which 60 kw.-hrs. per ton was quite a reasonable current consumption for the annealing of brass; he had no doubt that that could be much improved.

A Plea for the Arc Furnace.

Mr. W. R. Barclay agreed that we in this country were behind both with regard to the electric melting and heat treatment of metals, and one of the first steps towards remedying that condition of affairs was to discuss frankly the problems involved. Though the Paper was an excellent introduction to this discussion, he was disappointed that the arc furnace had not received more attention than it had. He had had close acquaintance with the problems and difficulties of the arc, top electrode, type of melting furnace, and the greater his experience the deeper became his admiration for it. In America it had received more attention than in this country, but even in America it had not received as much attention as it deserved. A number of mechanical improvements had been made to the arc furnace, which certainly tended to lessen the metallurgists' worries and difficulties. In arc furnace melting

there was not the same serious troubles as in other electric furnace melting practice with regard to refractories, and there was greater elasticity in choice of refractory materials. Again, there was the advantage that arc furnaces permitted a certain amount of refining. If one was always able to melt definitely pure materials in practice, then he believed every metallurgist would insist upon the management providing a high-frequency furnace; but, as one was very often dealing with large quantities of scrap, one needed some elasticity with regard to slagging and fluxing treatment. He would admit all that could be said about the danger of the absorption of carbon from electrodes, and so on, but with proper working that danger could be reduced to a minimum. Whilst admitting the advantages of high-frequency melting, he was not quite sure that he would endorse the author's statement that purer melting could be obtained with the high-frequency furnace than with any other type. It was remarkable what a high degree of purity could be obtained with the arc furnace, properly controlled. He emphasised the necessity for the close collaboration of the metallurgist and the engineer in design in order to produce ideal melting plant. The mechanical arrangements of most of the furnaces left a very great deal to be desired.

A Survey of Existing Methods.

MR. A. GLYNNE LOBLEY, discussing the rotating arc type of furnace, referred to the Watson furnace, which was of English design, and had certain outstanding advantages over the Detroit. The latter was a single-phase furnace, which fact might lead to trouble with the power supply authorities, but the Watson could be made three-phase, the electrical arrangement was out of the way of the operator, and there was very little fear of breaking electrodes. Dealing with the melting of aluminium, he said that about nine years ago he was faced with the problem of melting it electrically in bulk, and had had to rule out both the arc and the induction furnace. There were several difficulties in the use of the induction furnace for the purpose—the high conductivity of aluminium, "pinch" effect, and the difficulty with regard to the refractory—and he had built a furnace using carborundum troughs, with granular carbon as resister. This gave excellent results. Just after that the Baily furnace, on the same principle, was produced. The furnace he had built, which held about 15 cwts. of metal, had two longitudinal troughs, the metal being charged at one end and poured from the other by tilting the whole furnace. The furnace cost much less to run than the producer gas furnace which it had supplanted. The losses were reduced enormously. Mr. Lobley also referred to a small crucible type of furnace heated by external nickel-chromium resisters. The crucible held 60 lbs., the furnace being used for melting aluminium alloys in very small quantities for die casting. The cost of running was rather less than that of the gas furnace which it had supplanted, even though the electric furnace was kept hot all night and used only in the daytime. It was described in a Paper before the American Electrotechnical Society (Vol. 42).

Electric Heat-Treatment Furnaces Commercialised.

The advantages of electric furnaces for heat treatment of metals were not fully realised here, and there was a distinct fear that high capital cost was involved, but this was not always the case. Referring to the star-delta connection, he said he had used it eight or nine years ago on industrial annealing furnaces. These furnaces worked on three-phase, 440 volts. The dimensions of the smallest were 2½ ft. across and 6 ft. long; the dimensions of another were 5 ft. by 12 ft.; and there was another still larger. In addition to the "EFCO" type with the shielded resisters, the resisters running through slots in the refractory, he said there were others built in this country. In one type, the resisters, consisting of nickel-chromium strips, were held in metal supports in such a way that there was no shielding at all, so that hot spots were avoided. In this way it was possible to employ a higher wattage per sq. in. in the resister. Mr. Lobley showed a number of slides illustrating these furnaces. Continuing, he said that electric furnaces offered great opportunities for recuperation. With regard to the possibilities of high-frequency current for heat treatment, he mentioned a patented method in which currents of extremely high frequency were applied to bring about surface heat treatment. One could calculate the frequency which was necessary to locate the heating in the surface, and it would be possible to bring about surface heat treatment where required without having to raise the whole of the material to the required temperature.

DR. MAX HAAS (Deutsche Gesellschaft für Metallkunde, Germany) urged the necessity for supplying electrical energy cheaply in order to encourage the use of electric furnaces.

Cost Data Given.

MR. H. H. HAYES said he was with Mr. Campbell when the first Ajax-Wyatt furnace was put down in the Midlands to run on continuous 12-hour shifts, and he gave the following figures, taken from a typical week's run. The furnace was shut down from 12 noon on Saturday until 6 a.m. on Monday:—

Metal charged, 24.6 tons.
Metal poured as ingots, 24.1 tons.
Per cent. metal poured as ingots, 98.5.
Weight of splashings put back into furnace for re-melting, 0.602 per cent. of weight of metal charged.
Weight of skimmings and chippings put back into furnace after being washed, 1.91 per cent. of weight of metal charged.
Hours running, 168.0.
Hours melting, 126.0.
Hours standby, 42.0.
Units to melt per ton of metal charged, 240.
Units to melt per ton of metal poured as ingots, 243.
Units used during standby, 400.
Per cent. units used during standby to total units, 6.37.
Total units to melt per ton of metal charged, 256.
Total units to melt per ton poured as ingots, 260.
Total metal irrevocably lost, 2.5 per cent.

The figures of units to melt per ton varied considerably. Scrap losses also varied considerably, and when using about 30 per cent. of virgin material in the charge, the remainder being fairly heavy scrap, they averaged 2.5 per cent. Mr. Hayes compared his figures with those obtained from a furnace of the same type, except that it ran on 25 cycles, whereas the first furnace ran on 50 cycles. On a run of 1,000 tons the average loss was 2.54 per cent. In no instance was more than 10 per cent. of virgin metal used in the charge, the rest being fairly bulky scrap, mostly cartridge cases, and very little heavy scrap. The average weekly output of the furnace, which ran continuously, was 35.6 tons; the energy input was 65 kw. at 400 volts. At times, when labour was good, the furnace was run at what was considered to be its maximum efficiency, and he had obtained records showing that it actually melted with a consumption of 218 units per ton. The output under those conditions was 42½ tons per week. When running on an output of from 35 to 38 tons per week the energy consumed was 230 units per ton, which was not too bad. The figure of 42½ tons seemed to be high, but the furnace had actually melted and poured 600 lbs. per hour without any difficulty. With regard to residues, he said borax had been used in this furnace as a flux, and, this, apart from keeping the scrap losses down, resulted in easing the labour of chipping the lining; the material on the lining appeared to be more friable. It paid to sell the residues rather than to wash them and put them back into the furnace.

Swedish Practice.

MR. OTTO FRICK said that the short period of only six months' actual working of a new design of induction furnace for non-ferrous metals warranted the conviction that a lining for use in the melting of those metals would shortly be forthcoming. The problem of finding a suitable lining for non-ferrous metals did not offer greater difficulties than those already encountered and overcome in connection with steel melting, notwith-

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standing that these difficulties were of a somewhat different character. For brass, the problem had been solved already in a reliable and satisfactory way, a lining in the first 120-kw. brass furnace in the factory of A. B. Svenske Metallwerken, Vestersa, Sweden, giving promise of a very long life. There was misunderstanding with regard to the use of the induction furnace for non-ferrous melting, as common amongst makers as amongst users, caused by lack of knowledge in the matter. The induction type of furnace offered possibilities which had not been realised up to now. He described a Frick furnace in Sweden, operated at 130 kw. (as against only 60 kw. in the case of the Ajax furnace), which gave satisfaction in all respects, producing 12 tons of brass of uniform analysis in 24 hours. Quick transfer of heat and reliable alloying was secured without having to rely upon either pinch effect or on a V-shaped channel, but simply by utilising the rotary movement of the metal in the heating channel well known to all users of transformer furnaces. In order to keep the 120-kw. 600-kg. brass furnace hot, from 7 to 8 kw. were required. The total electrical losses in the furnace and step-up transformer remained at or below 3 per cent. The furnace produced from 18 to 19 casts of 630 kg. per day at slightly less than 200 kw.-hrs. per ton. In melting copper, making one cast of 100 kg. every half-hour, the energy consumption had been below 250 kw.-hrs. per ton in the case of pure copper, and between 270 and 300 kw.-hrs. per ton when melting bronze, with about 2 per cent. special alloy. To melt pure nickel in a 100-kw. furnace would require about 425 kw.-hrs. per ton; while cupro-nickel, with 20 and with 40 per cent. nickel, would demand respectively 300 and 325 kw.-hrs. per ton.

Refractory Position Unsatisfactory.

DR. WALTER ROSENHAIN, F.R.S. (National Physical Laboratory), said that the economy of the melting process was not merely a question of the transfer of energy from an electric current generator to the metal; it was also a function to some extent of the rate of loss of heat from the container. If the metal container were of an undesirable shape—for instance a large ring—it was bound to lose heat unduly fast. If it had to be subjected to a very violent temperature gradient by external cooling, the economy of the process was likely to suffer. The Ajax-Wyatt furnace seemed to be remarkably free from both those defects. He sympathised entirely with the complaint as to lack of advancement in regard to refractories, and it seemed to him that the refractories problem was a bugbear which was being allowed to stand in the way of the development of furnaces of this type in a way which it should not do. It would seem that a reasonable application of modern research methods to the problem should not fail to produce the desired result.

Importance of Insulation.

The suggestion of annealing and heat-treating by electricity was most attractive, and there was a great deal to be said for it, particularly if it were done in a tube furnace adapted in shape to the shape of the materials passed through it. To generate the heat within the strip seemed to be ideal, and the only disadvantage at present was the capital cost involved, but perhaps that would not be so serious in the future if it were possible to use moderate instead of high frequencies. Discussing the heat insulation of electric furnaces, he said that for some purposes it was best to provide good insulation. If the furnace were run continuously, heat insulation was good, because a stable condition of thermal equilibrium was reached and the heat insulation meant so much saving of heat. But if the furnace were used intermittently, the question of insulation assumed a different aspect. It had been shown in a Paper published in Germany that one could increase very much the overall efficiency of a furnace doing successive heats by cutting down the insulation. It was a question of whether the loss of energy due to cooling during the run was a bigger factor than the heating up of the insulation each time. Whilst agreeing that the provision of cheap electric current was necessary for the fuller development of electric melting and heat treatment, he said the advantages of electric working generally were much greater than would appear from a mere consideration of the costs involved. The general squalor and dirt of the foundry and rolling mill could be very largely reduced by the clean and odourless methods of electric heating, and that was a factor not to be under-rated. Anything which would improve the efficiency of the workers and increase their willingness to work was to be welcomed.

Author's Reply.

MR. CAMPBELL, replying to the discussion, said that the figures to which Dr. Brownsdon had taken exception were certainly obtained from a furnace working under favourable conditions, but they were actual records. The question of what work was being done was an important factor; Dr. Brownsdon did not make such metal as was made in South Wales. There were a considerable number of electric furnaces for annealing in this country of which he had experience, some of them being used for the continuous annealing of wire for submarine cables, in which case it was necessary to work to within very close limits, and to anneal in an atmosphere of nitrogen. They were giving completely satisfactory results. The whole of the wire in the Pacific cable—the longest in the world—was annealed electrically. Other furnaces of large dimensions had been erected for the heat treatment of aluminium for the Admiralty, and for various other operations of that sort.

High Frequency and Refining Conditions.

Replying to Mr. Barclay, he said he was not prepared to say that one could not refine in the high-frequency furnace. The art of refining metals such as steel, nickel, and so on depended upon the speed at which the hot metal was brought into contact with the slag. In the arc furnace there was a shallow bath and a large slag area. With the high-frequency furnace he had not expected efficient refining, because the slag appeared to be cold, but it was in fact very hot on the under side, and the speed with which the metal was brought into contact with the slag was enormously greater than in any other furnace. He personally considered that one should be able to refine fairly efficiently, if not very efficiently, with that furnace. Replying to Mr. Otto Frick, he said he was certain that great improvements would be announced before long in regard to linings, but he wished to be quite certain about the data obtained before stating that a certain lining was suitable for a certain metal. As to the capacity of furnaces, the 600-lb. furnace was often favoured largely because it was suitable for British brass mills, but there was no reason why it should not be of larger capacity. Furnaces of 12 cwts. were working fairly satisfactorily, and within a month or two furnaces of from 25 to 30 cwts. capacity would be working. The capacity of the individual furnace depended largely upon the size of the shop, the work to be done, and so on.

Cracking of Crucibles.

As to the statement by Dr. Rosenhain that his crucibles always cracked, and that he expected them to, he said they must be non-plumbago crucibles, because there was no trouble whatever in the high-frequency furnace with the plumbago crucible. It gave about four times the life of the non-plumbago crucible, melting the same metal, but the carbon-free crucibles were a problem. On the question of the insulation of annealing furnaces, he said that when designing these furnaces the programme of work was always taken into consideration; the proportion of working and non-working hours was considered in determining the insulation to be used.

"Trade Alloys."

The Institute of Metals receives such numerous inquiries for the names of the manufacturers of the thousands of "trade alloys" that exist, that it has been decided to compile a list of "trade alloys," together with particulars of their composition and uses, as well as the names of manufacturers or agents in Great Britain. Persons interested are invited to forward to the Secretary, 14, Members' Mansions, London, S.W.1, the following particulars:—(1) Name of alloy; (2) manufacturer or agent supplying; (3) composition; (4) in what form supplied; and (5) uses.

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Trade Talk.

G. R. CAWOOD & COMPANY, LIMITED, 4, South Parade, Leeds, have removed to 1, Cavendish Road, Leeds.

MR. GRANT BARCLAY, managing director of the Caledon Shipbuilding and Engineering Company, Limited, Dundee, has retired after thirty-one years' service.

AN OIL FURNACE in the premises of the Scottish Tube Company, Helen Street, Govan, was destroyed by an outbreak of fire which took place in the smithy on March 15.

BOLCKOW, VAUGHAN & COMPANY, LIMITED, Middlesbrough, have put in hand the dismantling of their Clay Lane Ironworks, which have been idle since the mid-war period.

NORMAN PEARSON & COMPANY, LIMITED, Crown Works, Lots Road, London, S.W.10, announce that Mr. Norman Pearson, Mr. S. O. Pearson and Mr. H. J. Bebbington have been retired from their services in the company, and all authority in any way to represent the company or act on their behalf is cancelled. The directors have appointed Mr. G. W. Hammond, who has had extended experience with the firm, as sales manager.

MR. C. K. EVERITT, director of Edgar Allen & Company, Limited, Sheffield, gave a lecture to members of the Darlington and District Association of Foremen Engineers and Chief Draughtsmen, at the Technical College, Darlington, on March 18, on "Present-Day Steels, Their Manufacture and Uses." The speaker dealt with alloy steels for constructional work and rail track work, and also with acid and heat-resisting steels, describing the processes of manufacture. He outlined briefly the principle and advantages of the electrical crucible furnace, which was not installed in this country at present. His firm, he said, hoped to instal at Sheffield shortly the first furnace of this kind.

A REPORT HAS NOW BEEN PUBLISHED to the effect that the Government of South Africa, for financial reasons, has dropped its proposal to undertake the building of steel works and plant in the Union. The workshops will be erected by private enterprise. The plan is to form a private company to organise and carry on the manufacture of steel, in which firms conducting the highly specialised business of locomotive construction abroad will be interested. The Government is to be interested financially and to be represented on the board of management. It is said that the board will also include representatives of such firms as Vickers, Limited, the Metropolitan Carriage and Wagon Company, Beyer, Peacock & Company, Manchester, and Lysaghts. The Government is practically assured that the whole of the preference shares in the proposed company will be taken up by British interests before the Bill dealing with the enterprise has been proceeded with.

THE BENGAL IRON COMPANY, LIMITED, announce that as forecasted at the last annual meeting a second blast furnace was put in operation in December, and the two furnaces have been working with satisfactory results, owing to the improvements made in the plant during the period of suspension. The foundries are employed nearly to their maximum output. The coal trade in India, however, has been very depressed for some considerable time, and the prices realised for surplus coal do not leave much margin for profit. The profit-sharing agreement with the Indian Iron and Steel Company, Limited, will this year show that the arrangement come to in 1925 was fully justified, and the board are of opinion that the result of the year will enable the deficit balance of £96,072 carried forward last year to be wiped out and leave a fair surplus. The chairman and Mr. Lincoln Chandler have returned from a visit to the company's properties and to those of the Indian Iron and Steel Company, Limited.

DURING THE HALF-YEAR ending June 30, 1926, the output of pig-iron by the Mysore Iron Works rose to 10,000 tons, the full rated capacity of the furnace. The increased output and the various measures of retrenchment helped to reduce the costs of production considerably, and in the case of the main products, the reduction was mainly 25 per cent., compared with the previous half-year. Some improvement was also noted in the sales, both in respect of quantities sold and the rates realised. The pipe foundry has been erected and started operation. Pipes of all sizes up to 16-in. diameter have been cast, but it will be some time before the labour can be trained so as to obtain the best results from the plant. The operation of the works during the half-year ended June 30 have resulted in a loss of Rs. 42,000 (£3,150), of which the amounts of Rs. 23,000 (£1,725) is directly attributable to the operation of the last half-year. "This result," the Prime Minister of the Mysore State averred, "cannot be said to be unsatisfactory if we take into consideration the experience of similar concerns in India and elsewhere."

Gazette.

THE PARTNERSHIP heretofore subsisting between Messrs. J. Heatley and C. Field, Spring Bank Foundry, Mill Hill, Blac'kburn, under the style of Heatley and Field, has been dissolved. Mr. J. Heatley will continue the business as Heatley & Son.

MESSRS. L. G. BLOWER, W. Whatton, J. A. Whatton and W. H. Whatton, engineers, Bingley Street, Wolverhampton, trading under the style of Whatton & Sons, have dissolved partnership. Mr. W. Whatton, Mr. J. A. Whatton and Mr. W. H. Whatton will continue the business.

AN ORDER FOR THE COMPULSORY WINDING-UP of the firm of C. E. Peel & Son, metal merchants, Swansea, was made by Judge Rowland Rowlands at Swansea County Court last week, the petitioners being two foreign banks. It was stated that in October last the company went into voluntary liquidation, and the statement of affairs of the liquidator showed a deficiency of £21,418, and the petitioners were holders of bills amounting to £18,000 out of this amount.

Personal.

MR. T. DOCKERAY, of Gray Street, Workington, has been appointed chief metallurgical chemist to the Baltimore Iron and Steel Company, U.S.A.

MR. F. E. BERRY, who joined the British Electric Transformer Company, Limited, in 1905, has been appointed manager and elected to a seat on the board, in place of the late Mr. George Berry.

MR. H. T. TIZARD has been appointed secretary to the Committee of the Privy Council for Scientific and Industrial Research on the retirement of Sir H. Frank Heath from that office on June 1 next.

MR. G. F. CASWELL has resigned his position as managing director of Caswell & Shearing, Limited, 6, Broad Street Place, London, E.C.2, and ceases to have any active interest in the company. Mr. H. L. Pirie has been appointed as chief engineer.

Wills.

ERROLL, W. M., of Abbot's Rood, Milnthorpe Road, Eastbourne, engineer £13,727

HASLAM, SIR ALFRED SEALE, principal of Haslam Foundry and Engineering Company, Limited, Derby £1,064,000

STOKES, SIR FREDERICK WILFRID SCOTT, of Ockham, Surrey, the inventor of the Stokes gun, and chairman and managing director of Ransomes & Rapier, Limited, Ipswich £55,467

FLEMING, W. YOUNG, St. Margaret's, Park Road, Paisley, shipbuilder and engineer, lately chairman and managing director of Fleming & Ferguson, Limited, of Paisley £62,619

Contracts Open.

Aldershot.—Ten dozen manhole covers, gutters, rainwater pipes and fittings, brackets, etc., for the Town Council. Mr. J. Neave, borough surveyor, Municipal Buildings, Aldershot.

Glasgow, April 9.—Bolts and nuts; brass cocks, etc.; cast-iron pipes, etc.; cast-iron castings; gas and steam tubes and fittings; malleable iron and steel bars, etc.; meters; meter brackets (steel), during twelve months from June 1, for the Gas Department. The General Manager, Gas Department, 30. John Street, Glasgow.

Oakengates, Salop, April 5.—(g) Manhole covers, (h) gully tops, (i) cast- and wrought-iron water tubing, hydrants, valves and stop-cocks, for period ending March 31, 1928, for the Urban District Council. The Surveyor, Council Offices, Oakengates.

Pontyclun, April 7.—550 lineal yards 14-in. dia., 2,100 12-in., 1,200 11-in., 1,300 9-in., 3,100 7-in., 3,700 6-in., and 350 4-in., together with necessary valves, hydrants, etc., for the Llantrisant and Llantwit Fardre Rural District Council. Messrs. Thomas & Morgan & Partners, civil engineers, Pontypridd. (Fee £10 10s., returnable.)

Sofia, Bulgaria, April 5.—Water piping and fittings, either of cast iron or steel, for the Bulgarian Ministry of Public Works. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,421.)

Southwell, April 7.—415 tons of 8-in., 7-in., 6-in., 5-in., 4-in., 3-in. and 2-in. cast-iron pipes and specials, for the Southwell Rural District Council. Messrs. Sands & Walker, the engineers, Milton Chambers, Nottingham. (Fee £3 3s., returnable.)

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IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—A relatively small attendance on 'Change on Tuesday was probably attributable not to any lack of interest on the part of purchasers, but to a determination to hold off the market until prices are more nearly approximate to their ideas of a reasonable figure. Once more is the Cleveland iron trade harvesting the evils of inflation. It was easy to force up the price of iron during the famine period of the coal strike; it is a good deal less easy to deflate prices now that those abnormal conditions have disappeared. But it is a necessary process which must be accomplished sooner or later, and better sooner than later. Ironmasters say that coke prices must fall first; coke-makers ask why they should cut prices when Cleveland pig-iron is selling at 80s. And so nothing is done. Ironmasters are living on old contracts, supplemented by such small orders as British consumers are compelled to place to cover their immediate needs, and our export trade has virtually disappeared. It is no use denying that prices must fall. Good foreign foundry pig-iron is actually being landed on the Tees at several shillings per ton below the price of Cleveland iron, and, of course, is cutting the latter out of all markets abroad. Probably the resistance of the Cleveland ironmasters to bear pressure is to some extent explained by the fact that the current output is passing immediately into consumption. Running contracts absorb practically the whole of the make, and there is no evidence of the accumulation of stocks of iron at any of the works. It is not therefore the present, but the forward, position which is disquietening. The disparity between British and Continental prices is less marked for hematite iron than in the case of the foundry quality, but still there is a difference of about 5s. per ton, and that is sufficient to divert business from British works to those of Continental rivals. Nor are any of the home consumers at all keen buyers, and hematite makers frankly admit that business is extremely quiet. There has been a good deal of price cutting, and East Coast mixed numbers can now be bought at 85s. per ton, but even that figure may be broken very soon. At all events, buyers are not convinced that the fall in prices has reached its limit, and so they are content to wait.

MANCHESTER.—There has been no greater freedom of buying operations on the Lancashire market for pig-iron this week than has been in evidence at any period this year, in spite of the lower prices at which supplies of all varieties are now obtainable. The fact of the matter seems to be that consumers are by no means satisfied that values are on a stable basis yet, and they are content to adhere to their policy of piecemeal buying until such time as they are reasonably sure that there is little to be gained by holding back. It is this spirit that has dominated the market during the past week, and the most that sellers are able to do is to pick up relatively small orders for early delivery.

THE MIDLANDS.—There is practically no scarcity in foundry pig-iron, as it is now possible to obtain supplies from most of the Midland furnaces. The prices which have been ruling for the past fortnight are maintained, and, although business is not good, the makers are loath to make any concessions. They point out the continued high price in furnace coke; consumers, on the other hand, consider that the furnaces will be forced to reduce their figures owing to the absence of buying on any large scale.

Metals.

Copper.—Fortunately prices of standard copper have not shown much change, all sections of the industry apparently being uncertain as to developments in the immediate future. At one time the market weakened distinctly, due to a lull in the trade demand and freer competition by sellers outside of the American Export Combine, but subsequently a rally ensued, making for a steadier feeling, as indicated above. The price in America only being slightly shaded, it seems apparent that producers are showing resistance, as they are reputed to be in a much better position after the heavy sales effected recently. The outlook in the German trade has certainly improved, and the general aspect of the consuming trades is viewed in a more hopeful light. Should the larger American producers carry out their intention of curtailing output to the extent suggested recently, this may help in strengthening the market in the long run, while the current price is still low.

Official closing prices of standard copper have been as follow :—

Cash : Thursday, £55 15s. to £55 17s. 6d. ; Friday, £55 15s. to £55 17s. 6d. ; Monday, £55 5s. to £55 7s. 6d. ; Tuesday, £55 to £55 2s. 6d. ; Wednesday, £54 17s. 6d. to £55.

Three Months : Thursday, £56 7s. 6d. to £56 10s. ; Friday, £56 7s. 6d. to £56 10s. ; Monday, £55 15s. to £55 17s. 6d. ; Tuesday, £55 12s. 6d. to £55 15s. ; Wednesday, £55 7s. 6d. to £55 10s.

Tin.—Values of standard cash tin have also been comparatively steady, notwithstanding the fact that conditions in the consuming industries are not particularly encouraging. In fact, the main feature has been the tightness of the market for actual metal and near-at-hand supplies. The premium thereon has been maintained at about £15 per ton, while there was only a slight increase in the home stocks.

Official closing prices of standard tin have been as under :—

Cash : Thursday, £312 15s. to £313 ; Friday, £311 15s. to £312 ; Monday, £307 10s. to £307 15s. ; Tuesday, £307 to £307 5s. ; Wednesday, £309 5s. to £309 10s.

Three Months : Thursday, £297 15s. to £298 ; Friday, £297 12s. 6d. to £297 15s. ; Monday, £296 12s. 6d. to £296 17s. 6d. ; Tuesday, £296 15s. to £297 ; Wednesday, £298 10s. to £298 15s.

Spelter.—The market after being weaker improved again on balance, in spite of the adverse American statistics indicating another increase in the American smelters' stocks. At present the metal presents no very material change, but still maintains a fairly firm undertone, due more particularly to rather more favourable reports from the Continent, whence sales have continued on a somewhat restricted scale.

The following are the week's prices :—

Ordinary : Thursday, £30 7s. 6d. ; Friday, £30 3s. 9d. ; Monday, £30 ; Tuesday, £29 16s. 3d. ; Wednesday, £29 17s. 6d.

Lead.—Stocks here at the present time are inclined to expand, but in view of the recent firmness of the market, probably fears in this direction are overdone. Buying by consumers has certainly receded from the scale of a short while since, but that such a volume of purchasing could be continued for long was necessarily out of the question.

The week's prices are appended :—

Soft foreign (prompt) : Thursday, £27 5s. ; Friday, £27 5s. ; Monday, £27 2s. 6d. ; Tuesday, £26 17s. 6d. ; Wednesday, £26 17s. 6d.

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